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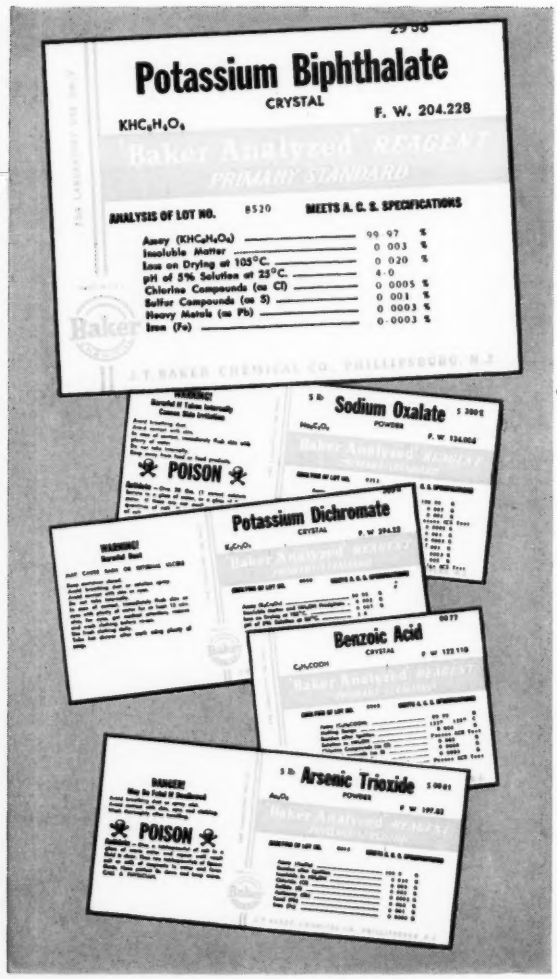

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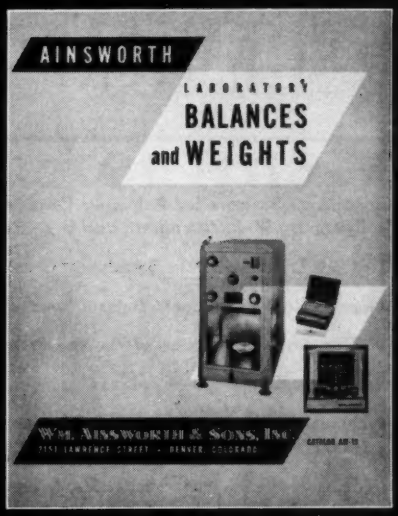

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8. EQUILIBRIUM. OXIDATION AND REDUCTION

A. RATE OF REACTION

8-1 Match. **Burn, raising question of why it needs energy of activation to start it, although once started it continues burning.**

*8-2 *Iodine clock reaction.* Stop-watch, two 400 ml. beakers. *Solution A:* 2 g. KIO_3 + 1000 ml. water. *Solution B:* dissolve 2 g. soluble starch in 500 ml. boiling water, then add 0.4 g. $NaHSO_3$ + 5 ml. 1 M H_2SO_4 + 500 ml. water. **Mix equal quantities of solutions A and B, pouring back and forth several times to mix thoroughly. Time the seconds it takes before the solution mixture flashes blue-black.**

8-3 *Effect of concentration.* Solutions A and B from 8-2, six 400 ml. beakers. In beakers place (1) 160 ml. A, (2) 160 ml. B, (3) 80 ml. A + 160 ml. water, (4) 80 ml. B, (5) 40 ml. A + 240 ml. water, (6) 40 ml. B. **Have three students assist you. At time zero mix 1 + 2, 3 + 4, and 5 + 6; note times to flash blue-black for concentrations 1, $^1/_2$, and $^1/_4$, respectively.**

8-4 Recall 2-17, dust explosion, the effect of increased surface available for reaction (the active mass).

8-5 *Effect of temperature.* Solutions A and B from 8-2, six 400-ml. beakers, hot-plate or burner, trough of cracked ice. All pairs of beakers are to contain 160 ml. A and 160 ml. B, respectively. Before lecture place one pair of beakers in the cracked ice; the second pair leave at room temperature; for the third pair bring the beaker containing KIO_3 nearly to boiling, leaving solution B at room temperature. **Have three students assist you. At time zero mix the contents of each pair, pouring back and forth three times; then hold each mixture aloft, Statue of Liberty fashion. Solutions will flash blue-black in progressively longer periods as the temperature is lowered.**

*8-6 *Old Nassau reaction.* *Solution A:* 15 g. KIO_3 + 1000 ml. water. *Solution B:* dissolve 4 g. soluble starch in 500 ml. boiling water, then add 15 g. $NaHSO_3$ + 500 ml. water. *Solution C:* 3 g. $HgCl_2$ + 1000 ml. water. **Mix equal volumes of B + C + A in that order. Solution turns bright orange, then blue-black. Colors appear sooner when less of solution C is used.**

B. IRREVERSIBLE REACTIONS

8-7 Mg ribbon, HCl-aq., test tube. **Demonstrate H_2 off, ignite.**

8-8 $AgNO_3$-aq., NaCl-aq., test tube. **Demonstrate AgCl precipitation.**

C. REVERSIBLE REACTIONS: SHIFTING EQUILIBRIUM

8-9 Recall 3-5, where $4H_2O + 3Fe \rightleftarrows Fe_3O_4 + 4H_2$ is reversible, the relative concentrations at equilibrium depending upon temperature.

8-10 $FeCl_3$-aq., NH_4CNS-aq., KCNS, NH_4CNS, $Fe(NO_3)_3$, NH_4Cl, four 600 ml. beakers, one 2-liter beaker, 4 stirring rods. **Mix small quantities of Fe^{+++} and CNS^- with about 1600 ml. water to give an orange-yellow (not red) solution. Distribute equally among four beakers. Shift equilibrium by adding Fe^{+++}, CNS^-, or the solids. Deep red $FeCNS^{++}$ forms.**

8-11 *Common-ion effect.* Phenolphthalein indicator solution, NH_4OH, NH_4Cl, 600 ml. beaker, stirring rod. **Add few drops of indicator to 400 ml. water + 50 ml. NH_4OH. Shift the equilibrium to lower OH^- by adding solid NH_4Cl: red solution turns pale pink.**

*8-12 $AgNO_3$, NaOAc, NH_4NO_3, saturated AgOAc, 3 test tubes. **To 10 ml. saturated AgOAc in two test tubes add solid $AgNO_3$ or NaOAc; the common ion effect causes precipitation of silver acetate. NH_4NO_3 has no effect on saturated AgOAc.**

8-13 *Changing temperature.* Two sealed glass tubes, each containing 1 g. PBr_5. Two tubes of N_2O_4 gas, dry ice, burner, acetone, thermos bottle. Make dry ice-acetone mush (CARE: INFLAMMABLE). **Heat a PBr_5 tube: forms reddish-brown Br_2 + PBr_3. Heat one N_2O_4 tube, and place the**

Turn the page for additional demonstrations

*Footnotes

8-2 The iodine clock and the Old Nassau solutions should be made up fresh, the week of the lecture. Experiment with them the day of the lecture. When properly operating, the effects are striking.

8-6 So named because it turns orange and black, colors of the House of Nassau, and of Princeton University whose Old Nassau Hall was the first under graduate chemistry laboratory in the world.

8-12 Be sure the silver acetate (AgOAc) solution is saturated, or this will not work.

8-15 The reaction with Na_2O_2 and paper was reportedly the origin of the fire in a Navy flat-top in Boston harbour in 1953.

8-19 The drops of $FeCl_3$ are added to the Cl_2-aq. to make it electrically conducting.

Labels for topic 8. (For code, see instructions for assembling kits, J. Chem. Educ., **32**, 12A(1955).) 8-2-*Stock Solution A:* 2 g. KIO_3 + 1000 ml. H_2O. 8-2-*Stock Solution B:* 2 g. starch + 0.4 g. $NaHSO_3$ + 5 ml. 1 M H_2SO_4 + 1000 ml. H_2O. 8-6-*Stock Solution A:* 15 g. KIO_3 + 1000 ml. H_2O. 8-6-*Stock Solution B:* 4 g. starch + 15 g. $NaHSO_3$ + 1000 ml. H_2O. 8-6-*Stock Solution C:* 3 g. $HgCl_2$ + 1000 ml. H_2O. 8-7-*w*-Mg ribbon, 8-7-*N*-HCl aq., 8-8-*d*-$AgNO_3$ aq., 8-8-*d*-NaCl aq., 8-10-*N*-$FeCl_3$ aq., 8-10-*N*-NH_4CNS aq., 8-10-*J*-KCNS, 8-10-*J*-NH_4CNS, 8-10-*w*-$Fe(NO_3)_3$, 8-10-*J*-NH_4Cl, 8-11-*d*-phenolphthalein soln., 8-11-*N*-NH_4OH, 8-11-*J*-NH_4Cl, 8-12-*w*-$AgNO_3$, 8-12-*w*-NH_4NO_3, 8-12-*w*-NaOAc, 8-12-*N*-sat. AgOAc, 8-13-*N*-acetone, 8-14-*J*-powdered charcoal, 8-14-*J*-KNO_3, 8-15-*w*-Na_2O_2, 8-15-*w*-Al powder, 8-15-*J*-tissue paper, 8-16-*w*-granulated sugar, 8-16-*w*-granular $KClO_3$, 8-16-*d*-conc. H_2SO_4, 8-17-*d*-glycerine, 8-17-*w*-$KMnO_4$, 8-19-*N*-$FeCl_3$ aq., 8-19-*J*-1 × 2″ iron plate and lead plate, 8-19-*N*-NaCl aq., 8-19-*N*-Cl_2 aq., 8-20-*N*-$FeCl_3$, 8-20-*N*-Cl_2 water.

other in dry ice mush: colorless N_2O_4 forms at low temperatures, reddish-brown NO_2 at high temperatures.

D. OXIDATION AND REDUCTION

8-14 Powdered charcoal; KNO_3 in a 5 cm. porcelain evaporating dish over burner, spoon. **Darken room. Dust charcoal into very hot molten KNO_3 (CARE).**

*8-15 Na_2O_2, Al powder, tissue paper, water pistol, two 12 × 12″ squares asbestos. **Sprinkle Na_2O_2 on tissue paper (CARE, KEEP HANDS AND FACE AWAY), then squirt few drops water upon it: violent flare-up. Sprinkle Al dust on 4 g. Na_2O_2 (CARE, KEEP HANDS AND FACE AWAY, SQUINT EYES), then squirt a few drops water upon it: violent flare-up.**

8-16 A 6 × 6″ asbestos square, granular $KClO_3$, granulated sugar, conc. H_2SO_4. Mix carefully (**CARE, DO NOT GRIND**) equal volumes of $KClO_3$ and sugar, and pile upon the asbestos. **Add (CARE) drops of conc. H_2SO_4: violent flame.**

8-17 $KMnO_4$, glycerine, paper cup full of finely powdered $KMnO_4$ on 6 × 6″ asbestos. **Pour in 0.5 ml. glycerine. Fire occurs after 30 second delay.**

8-18 Electricity produced in oxidation-reduction reactions. Recall experiments 7-6 and 7-7, couples for generating electricity.

*8-19 $FeCl_2$-aq., Cl_2-aq., 1 × 2″ iron plate, 1 × 2″ lead plate, salt bridge as in 7-2, large galvanometer with wire leads. Set up cell Fe/Fe^{++}/bridge/Cl_2-aq. containing a few drops of $FeCl_2$/Pb. **Current generated as Cl_2 is reduced to $2Cl^-$, and Fe^{++} is oxidized to Fe^{+++}.**

8-20 Electricity consumed. Setup as in 8-19, but replace the galvanometer by two dry cells and the $FeCl_2$ by $FeCl_3$. **Pass electric current: reaction of 8-19 is reversed, and Cl_2 gas bubbled off positive pole, while the electrons flow through the wire to the negative pole where the Fe^{+++} is reduced to Fe^{++}.**

Next month's Tested Demonstrations in General Chemistry

9. ATOMIC STRUCTURE. RADIOACTIVITY

For a complete list of topics for 1955–6 see J. Chem. Educ., 32, 28–9(1955)

Sir Robert Kane

(See page 404)

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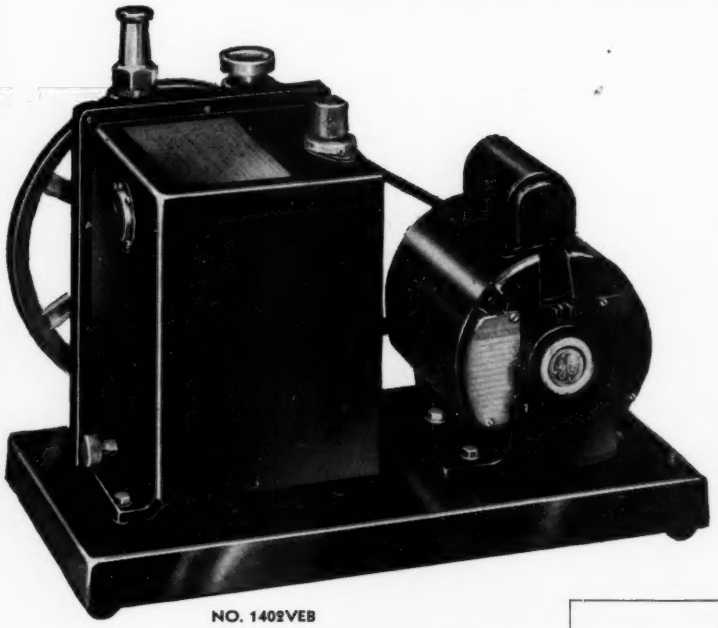

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Editor's Outlook

For many years industry has been contracting a debt to education. Now the payoff is beginning. Whether or not the compound interest on the principal will accumulate faster than the payments remains to be seen, but at least the premiums that are coming in are beginning to look substantial.

We do not accuse industry of failing to recognize its obligation in the past, but we know that debtors have a way of keeping hidden until the force of circumstances makes them "shell out." When the grocery stops delivering and shuts off the flow of provisions, then the customers start paying their bills. Industry is seriously worried about its supply of technical manpower from the colleges and schools and is trying to do something about it.

This is a very healthy sign. Up to a certain level we regard education as a governmental monopoly, on the theory that every boy and girl should be equipped to take an intelligent place in society. But beyond this point, where education begins to serve other purposes, vested interests appear. The individual can be expected to bear part of the costs—directly or indirectly—since he is the chief beneficiary. Industry gets direct benefits which it has no right to get for nothing. Industry's voluntary contributions at this point are but a means of applying corporate taxes to educational purposes. We neither can nor should regard such contributions as mere philanthropy. Perhaps we shall some day levy such corporate taxes directly. Industry should regard aid to education as part of its tax bill, even without legislative sanction.

At the present time industry's aids to education take several forms: undergraduate scholarships; graduate fellowships; grants in aid, either to students or to institutions directly; unrestricted gifts to general funds; sponsored research.

A good account of this activity, especially as it applies to one institution, appeared in an article by Herbert P. Catlin in the March number of the *Rensselaer Alumni News*. Eight corporations provide full, four-year scholarships to Rensselaer, usually including tuition, books and supplies, an overhead grant to the college, and sometimes subsistence for the student.

Graduate fellowships have been part of the educational financial picture for so long that nothing needs to be said about them. Many large industrial corporations maintain such fellowships at several institutions simultaneously. Sometimes these fellowships are restricted to a narrow field, but the present tendency is toward greater freedom.

Unrestricted gifts to the college budgets are not so common but are appearing more frequently. Four of these are listed in the account just mentioned. Such gifts are "an expression of confidence in the capacity of the college administration and in the contribution made by the whole institution."

Many of the large corporations now have their own internal scholarship and fellowship programs, providing such educational aid for their own employees or even for their children. Employees, on leave of absence, are sent away for graduate training with all expenses paid. This practice is of course in the self-interest of the corporation rather than an educational aid.

A new method of educational aid, of increasing importance, is sponsored research. The budgets of some of our larger educational institutions contain millions of dollars from this source. Much of this comes from industry, although the largest sponsor for research is the government. This is an indirect aid to education. Many graduate students are employed on these contracts, getting not only subsistence but valuable educational experience as well. Indeed, many institutions will not accept research contracts unless they contribute directly to their graduate educational programs. Even the semi-independent Research Institutes afford valuable graduate training.

But attention must also be given to the teacher as well as the student, and this is not altogether over-

(Continued on page 416)

CONTINUOUS REACTORS FOR PREPARING ORGANIC CHEMICALS[1]

C. F. H. ALLEN, J. R. BYERS, JR., W. J. HUMPHLETT, and D. D. REYNOLDS
Eastman Kodak Company, Rochester, New York

For more than a century essentially the same manipulative procedure has been followed for the preparation of organic substances. The components are mixed in a container of suitable size, to which there are attached the various accessory pieces of apparatus (condensers, stirrers, dropping funnels, etc.) and which is fitted for heating or cooling, according to the nature of the reaction. Such a procedure is conveniently known as a "batch process."

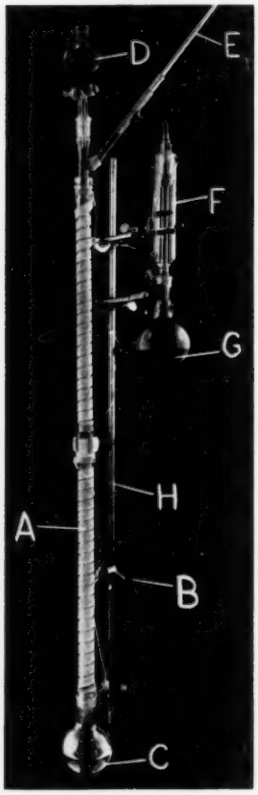

Figure 1

In spite of its general application, as evidenced by its long use, there are several restrictions on the employment of this type of apparatus. It has a limited capacity, whether the volume is a few milliliters or several thousand gallons. Large-scale production requires considerable space, as well as a large capital investment. A considerable portion of the "reaction time" consists in heating the mixture to reaction temperature and cooling it thereafter. The first molecules of product formed are subjected to an elevated temperature for prolonged periods of time: if the substance is sensitive to heat, decomposition may and usually does occur, as evidenced by tar formation. Furthermore, the product first formed may undergo subsequent undesired reactions, giving rise to by-products. Most organic reactions come to an equilibrium which can be displaced in the desired direction by removal of the products. This is possible only in a limited number of instances.

A piece of apparatus has been devised in these laboratories that circumvents the undesirable features just outlined. It is called a "continuous reactor" since a given reaction takes place in it as long as the starting materials are supplied and the product is removed. It is not to be confused with a "continuous process," which ordinarily involves a series of reactions or a complete mechanical operation. A few instances of the latter type are described in "Unit Processes" (*1*). This new apparatus can be modified to handle several types of reaction. It is also possible to increase its size to accommodate larger volumes of reactants. It can be built from apparatus that is standard equipment in most laboratories. Larger sizes employ commerically available "Pyrex pipe."

DESCRIPTION

The essential features of the continuous reactor are: (1) a vertical tube filled with glass helices or Berl[2] saddles, depending upon the size of the tube; (2) a receiver; and (3) a means of admitting the reactants at the desired rate. Modifications of this reactor have a means for countercurrent circulation of a volatile component, or irradiation. The following descriptions are given in more detail.

General Reactor

This apparatus on a laboratory scale as shown (Figure 1) consists of a column 100 cm. long and 2 cm. inside diameter, in two 50-cm. sections, packed with $^1/_8$-in. glass helices. The column is heated by two 275-watt flexible heating tapes[2] *A*, 6 ft. long and $^1/_2$ in. wide, with lead wires *B* connected to Powerstat or Variac voltage regulators (V.R.) on 110-volt lines. The heating element may be covered with asbestos tape if required. At the bottom of the column is a 500-ml. flask *C* for receiving the product. At the top of the column is a 250-ml. addition funnel *D* (a cylindrical shape is convenient for calibration of volume and winding with heating tape). The addition funnel is connected to the column through a section having a side arm provided with a thermometer *E* and downward condenser *F* leading to a 500-ml. flask *G*, which has an outlet to the atmosphere for effluent gas and for collecting any distillate. The apparatus, which is joined through 29/42 and 24/40 standard-taper glass joints, is clamped to a single ring stand *H*.

This apparatus can be considerably enlarged to

[1] Communication No. 1699 from the Kodak Research Laboratories.

[2] These are listed by most laboratory supply companies.

increase the capacity by using standard Pyrex pipe, either 2 or 4 in. in diameter, joined by flanges with Teflon gaskets, and with a larger receiver and dropping funnel. With a 4-in. column, the funnel is conveniently made from a 5-l. flask; a similar piece of equipment is used as a receiver, the effluent being withdrawn at the bottom from time to time.

Modification for Countercurrent Circulation

This equipment as shown (Figure 2) consists of a column 50 cm. long and 2 cm. inside diameter, packed with $^1/_8$-in. glass helices and wrapped with $^1/_2$-in. heating tape *A*. Near the bottom of the column is a side-arm connection *B* to a three-neck flask reservoir *C*. Vapor supplied by boiling the liquid in the reservoir is forced to circulate via *B* through the column, the excess escaping at the top through the side arm *D* connected to a Friedrichs condenser *E*. The bottom of the condenser is connected to a Y-shaped section with an outlet *F* for effluent gas and a return *G* for distillate to the reservoir. The tip of the return tube is beneath the surface of the liquid in the reservoir. At the top of the column is a 250-ml. dropping funnel *H* for admitting reactants to the column. At the bottom of the column is a 500-ml. flask *I* for receiving the product.

Since the product that collects in *I* might otherwise contain a considerable quantity of the volatilized circulating liquid, it may be advantageous to insert a heated column *K* packed with $^1/_8$-in. glass helices similar to *A* between the receiver and the tube *B;* this will result in removal of most of the volatile reactant. It is recommended when thionyl chloride is being used.

Reactor for Chlorination by Sulfuryl Chloride, and for Esterification

For Chlorination. The apparatus (Figure 3) is built of standard parts, except the alembic *F* (Ace Glass Co.), Vicor tube *E*, and condenser-alembic *C* (Figure 4). The latter has to be made specially; Pyrex can be used for tube *E* without much loss in yield. The apparatus consists of a 5-l. flask *A* equipped with a sectional, 2-cm. inside diameter reaction column *C, D, E,* at the upper end of which is attached an alembic *F* having an inlet tube *M*. The opening at *M* serves to introduce the substance to be chlorinated; this may conveniently be done by a pump. Alternatively, a Y-tube can be substituted for the alembic, in one arm of which is a dropping funnel with a pressure-equalizing tube. An efficient condenser *G* surmounts the column; tube *H* leads from the upper end to the pair of reflux condensers *I, J*. Condensed reagent is returned via *K*, which extends to the bottom of flask *A*, while gas escapes at *L*. Tubes *H* and *K* are preferably of glass, though polyethylene tubing can be employed. The supply of sulfuryl chloride is renewed by means of the funnel *N*. A Glas-Col heater *B* is used. Columns *D* and *E* are packed with $^1/_4$-in. glass helices, and *C* and *D* are jacketed for steam heating. Tube *E* is irradiated using three G. E. sun lamps (275 R-40).

For Esterification. The preceding apparatus is simplified by the following changes: Alembic *F* is replaced by a Y-tube bearing a dropping funnel. This is surmounted by an additional, packed reaction tube, to which is attached an azeotropic head in the usual manner. A second modification has been devised for bromination.

DISCUSSION

With this type of apparatus the rate is the most important feature. It is most useful with reactions that proceed rapidly. Some study may be required to discover the most favorable conditions of time and temperature for obtaining maximum yields, which

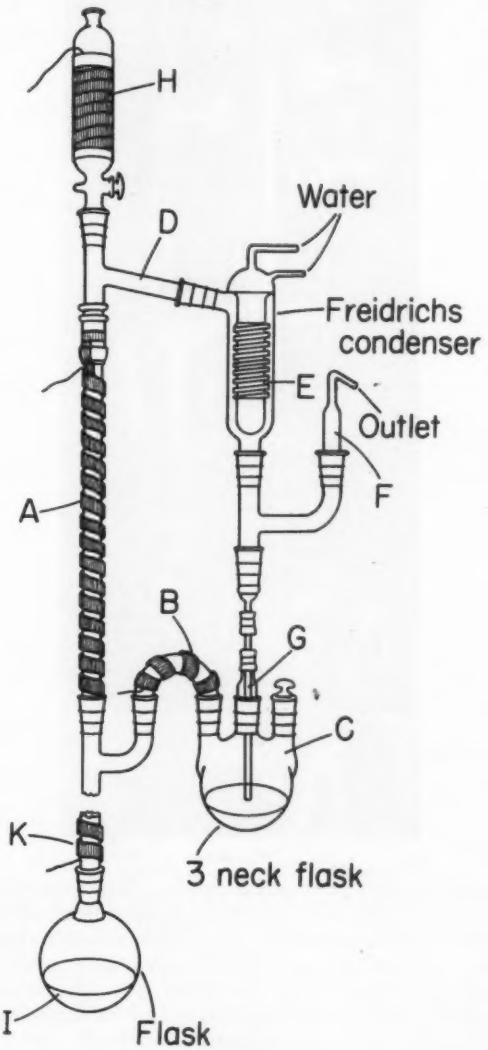

Figure 2

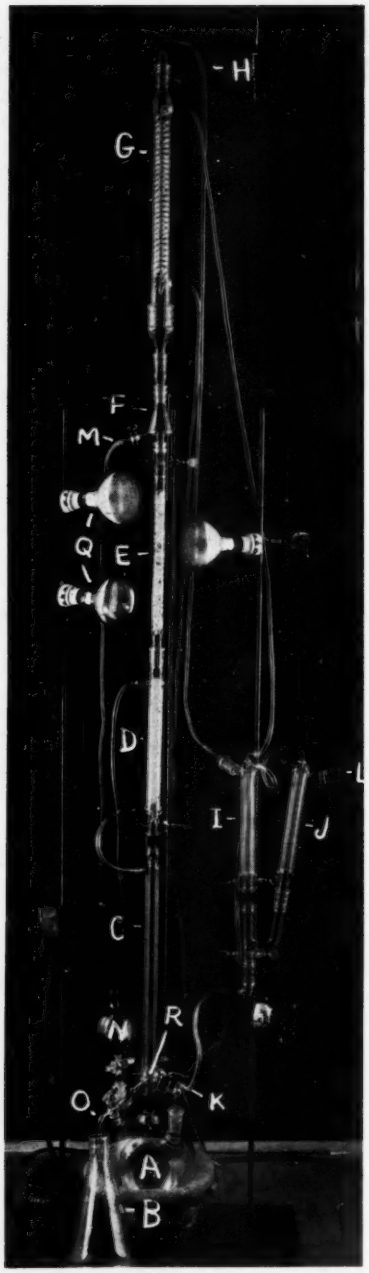

Figure 3

should be practically quantitative. When conversion is low, it usually indicates a too rapid rate of addition or too low a temperature, but it is also possible that an excess of one reactant or a recirculation might be beneficial. The latter condition prevails in slow reactions, such as esterifications and bromination of acids; even in these instances considerable reduction in time may compensate for a somewhat lower yield.

The time that is required for a given quantity of substance to pass through the column depends on the size of the packing, the length of the column, and the viscosity of the liquid. For instance, in a 2- × 100-cm. column packed with 1/8-in. glass helices, xylene requires three minutes to emerge after it has been admitted, whereas a benzaldehyde-ethyl malonate mixture takes six minutes. A 4-in. × 5-ft. column containing 1/2-in. Berl saddles and a 2-in. × 8-ft. column containing 1/4-in. Berl saddles permits acetic acid to pass through in 45 seconds.

The advantage of the continuous reactor over the batch process is very marked in the chlorination of the xylenes. Not only can good yields be obtained, but the monochlorinated product can be collected and rechlorinated in the same apparatus. There is no decomposition on distillation, such as has been observed when the crude material from a batch process is distilled, nor is there any tar; the product is almost white after one separation. This is attributed to the relatively short time the reactants are heated and irradiated, in contrast to the long treatment required with a batch. Furthermore, the reaction is easily controlled using the continuous reactor; over-chlorination and decomposition are at a minimum.

In addition to the reactions illustrated, the continuous reactors have been used to make alkyl bromides and cyanides, for hydrolysis, and for isocyanate formation by the phosgene method.

EXPERIMENTAL

The following examples illustrate the application of the continuous reactor, and also serve to point out its good features as well as its limitations. The substances made have been selected to show the varied types of reaction and general applicability, and the uses of each piece of apparatus. As a guide for operation with larger-sized runs, the rate per hour is given in most instances; this was calculated from the quantities used.[3]

General Reactor

Ethyl Benzalmalonate. This preparation is an aldol-type condensation, catalyzed by piperidinium ion, and is commonly referred to as the Knoevenagel reaction.

$$C_6H_5CHO + H_2C(COOC_2H_5)_2 \rightleftharpoons C_6H_5CH{=}C(COOC_2H_5)_2 + H_2O$$

The best batch procedure previously used (*2*) employed azeotropic distillation to remove the water formed. Since all the earlier data were available, a comparison of the conditions and yields of batch and continuous-reactor methods of preparation is given in the table.

[3] The experimental reactor first used contained a series of thermometers so that the inside temperature could be determined. The voltage-regulator setting that gave this temperature in this size of apparatus was thus determined. When studying a new synthesis, the setting that will cause the solvent or volatile reaction product to distill or reflux can be found quickly by experiment; this affords a measure of the inside temperature. The temperatures of reaction are only approximate, *i. e.*, plus or minus a few degrees.

The catalyst was piperidinium benzoate, a slight excess of piperidine favoring increased yield. In one instance, in which the use of piperidine was omitted, the reactor column was packed with a weakly basic ion-exchange resin, Amberlite IR-4B, which served as the basic component of the catalyst (*3, 4*). From the table it is obvious that the enormous difference in reaction time more than compensates for the ten per cent lower yield.

The V.R.'s were each set at 65 to maintain an internal column temperature just high enough to cause slow distillation of water from the top of the column. The yield by the continuous-reactor method was determined by running the component mixture through the column and working up the effluent, using comparable quantities. In each instance, a little unchanged aldehyde distilled with the water and was not estimated; the yield was based on the malonic ester. In each run, 2–5 g. of "tar" was left after distilling the ester. The boiling points and the melting point agreed with those recorded in the literature.

Benzoylacetanilide. The preparation of benzoylacetanilide is an example of the synthesis of an amide from an ethyl ester and a liquid amine.

$$C_6H_5COCH_2COOC_2H_5 + H_2NC_6H_5 \rightarrow C_6H_5COCH_2CONHC_6H_5 + C_2H_5OH$$

A mixture of 46.6 g. (0.5 mole) of aniline and 105.7 g. (0.55 mole) of ethyl benzoylacetate is admitted at the top of the column which is maintained at a temperature of about 135° with V.R. settings of 70. As the reaction takes place, alcohol distills from the top of the column. The rate of formation is 212 g. of crude product per hour. The product is collected in the receiver and, at the completion of the reaction, is rinsed from the column and the receiver flask with a total of 100 ml. of hot xylene. The xylene mixture is cooled, diluted with 100 ml. of petroleum ether, and the crystals are collected by suction filtration. The yield of almost white, dried crystals is 106 g. (89 per cent) melting at 104–5°. The product, recrystallized from 390 ml. of benzene, amounts to 95.8 g. (80.3 per cent) of white crystals melting at 105.5–6.5°. By the batch process, in one hour on a 0.2-mole run the yield is 76 per cent (*5*).

General Reactor with Countercurrent Distillation

Palmitoyl Chloride.

$$n\text{-}C_{15}H_{31}COOH \xrightarrow{SOCl_2} n\text{-}C_{15}H_{31}COCl$$

This preparation demonstrates very well some of the advantages of a continuous reactor. The time during which the sensitive product is subject to heat is shortened from the hours of the batch procedure to less than five minutes. It gives a light-colored product that could probably be used directly for most purposes; for this reason, it is advantageous to use the previously mentioned additional heated column between the receiver and tube *B* (Figure 2) to remove the bulk of the thionyl chloride. The over-all purity of the palmitoyl chloride is dependent on the quality of the palmitic acid. Since no suitable solvent for the latter was found, it is melted in the dropping funnel (wound with a heating tape) and admitted to the column as a liquid.

Fifty grams of palmitic acid, m. p. 61–2°, is melted in the dropping funnel above column *A*. Concurrently, the thionyl chloride still is started, the upper part of the column being filled with the vapor, and regulated to give a constant, steady reflux. The melted palmitic acid is added over a period of 25 minutes (which is at the rate of 110 g. per hour). The crude acid chloride contains about 27 per cent of thionyl chloride, which is removed by a short warming under reduced pressure on the steam bath. The yield is considered to be theoretical since infrared examination shows the absence of carboxyl groups. Palmitoyl chloride can be distilled at very low pressures (*e. g.*, b. p. 110°/15–24μ); n_D^{25} 1.4489, the product being water-white. Oleoyl chloride (b. p. 185–90° at 1 mm., 89–109° at 25μ, n_D^{25} 1.4582) and ricinoleoyl chloride, (b. p. 205–10° at

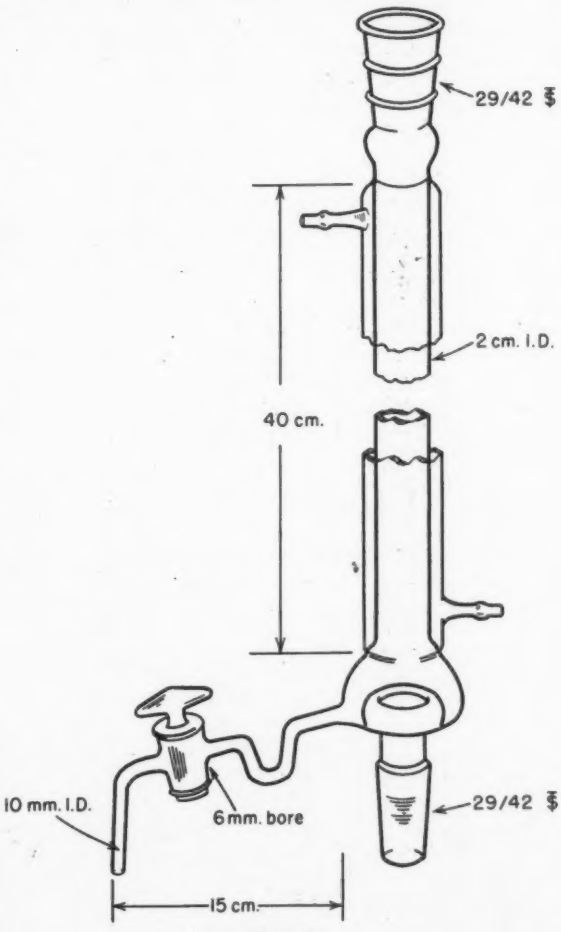

Figure 4

8 mm., 125–30° at 25μ, n_D^{25} 1.4759) can be prepared similarly. Only small lots can be distilled at the higher pressures given.

Chlorination Reactor. The side-chain chlorination of *p*-xylene, using sulfuryl chloride and benzoyl peroxide, gives a mixture of 4-xylyl chloride and 1,4-xylylene dichloride, along with very little of polychloro derivatives; there is no tar or black coloration as is encountered with direct chlorination (*6*) or in a batch reaction. In the latter instance, the yield of dichloride was only 29–30 per cent and it was quite yellowish, except when a very small amount (21 g.) of xylene was chlorinated in the sunlight (*7*). Irradiation, which is essential, is much better using the tube than in a batch process.

Steam is passed through the jackets of columns *C* and *D* (Figure 3) and cold water through condensers *G*, *I*, and *J*. The lights are turned on at this point. Three and one-half liters of sulfuryl chloride is placed in the flask *A* and heated, the rate of refluxing is adjusted so that there is a steady return from condenser *G*, while the heated columns *C* and *D* prevent any of the reagent from flowing down to and out of the take-off tube *O*. The benzoyl peroxide catalyst is dissolved in the liquid to be chlorinated, which is introduced by a pump at point *M;* the product is removed at *O*. Sulfuryl chloride is replenished through *N*.

One kilo of *p*-xylene, m. p. 12–13°, containing 10 g. of benzoyl peroxide, is passed through the apparatus at the rate of 400 g. per hour. The product removed at *O* is mixed with an equal volume of ligroin (b. p. 90–120°) and left in the icebox for 18 hours. The 1,4-xylylene chloride that crystallizes is collected on a filter, rinsed with ligroin, and air dried; m. p. 97–9°. The yield of white product is 600–680 g. (36–41 per cent). Upon distillation of the filtrate, 410–84 g. (40-7 per cent) of 4-xylyl chloride (b. p. 75–80° at 4–6 mm.) is obtained; there are about 145 g.(±8 per cent) of a low-melting fraction (m. p. 63–8°) and a residue of about 35 g. The low-melting fraction is a mixture of the dichloride and over-chlorinated material.

In a similar manner, 800 g. of 4-xylyl chloride, passed through the column at the rate of 1200 g. per hour, gave 373 g. (37 per cent) of the 1,4-dichloride, with recovery of half the xylyl chloride, and 50 g. of a low-melting (80–5°) mixture. No attempt was made to establish the optimum conditions for a more complete reaction.

Likewise, *m*-xylene, at the rate of 430 g. per hour, gave 460 g. (35 per cent) of 3-xylyl chloride (b. p. 198–200°), 84 g. of an intermediate fraction (b. p. 200–50°), 811 g. (48 per cent) of the 1,3-dichloride (b. p. 250–60°), and 63 g. of residue.

Esterification and Bromination. Since these reactions occur at a slower rate, it is necessary to collect and recirculate the effluent several (at least three) times to obtain good yields. Even so, the time involved is considerably less than that in the batch process. For instance, γ-chloropropyl acetate is obtainable in a 72 per cent yield after three passes which take two hours (90 per cent yield by the batch process over nine hours) (*8*). The bromination of butyric anhydride requires four passes per mole over a period of 7 minutes; the distilled product is converted into either acid (addition to cracked ice) or ester (mixed with ethanol and let stand overnight). The yields are 81–5 per cent whereas by the batch procedure they are 74–8 per cent.

Since this work was completed, two instances of continuous esterification, both of hydroxy acids, have appeared. In one (*9*), methyl lactate is obtained in a yield of 75 per cent, in what appears to be a slow reaction; the ester is isolated by azeotropic distillation and fractionation. In the other (*10*), citric and aconitic acids were esterified, using increased pressure and several passes; the authors emphasize the advantages of a short time of heating with consequent high quality of product.

ACKNOWLEDGMENT

We take pleasure in acknowledging the technical assistance of D. M. Burness, D. W. Stewart, and Thelma Davis, of these laboratories, and of W. Blum and G. Y. Brokaw, of Distillation Products Industries.

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Preparation of Ethyl Benzalmalonate

Type of run	*Solvent*	*Moles ester*	*Moles aldehyde*	*Time*	*Yield*	
					g.	*%*
Batch[a]	C_6H_6, EtOH	0.63	0.67	16 hrs.	44	25
Batch[b]	C_6H_6, EtOH	0.63	0.67	48 hrs.	135	86
Batch[b]	C_6H_6, EtOH	0.63	0.67	48 hrs.	125	80
Batch[b]	C_6H_6	0.63	0.67	18 hrs.	140	89.3
Batch[b]	C_6H_6	0.63	0.67	18 hrs.	142	90.8
Continuous[c]	C_7H_8	0.63	0.63	65 min.	52.2	33.4
Continuous	C_7H_8	0.315	0.315	90 min.	64.2	82.1
Continuous	none	0.70	0.77	30 min.	141	81.3
Continuous	none	0.70	0.735	30 min.	140.5	81
Continuous	none	0.692	0.692	30 min.	140.6	82
Continuous[d]	none	0.63	0.67	40 min.	22	14

[a] Usual apparatus—simple refluxing.
[b] Azeotropic removal of water.
[c] Excess benzoic acid used.
[d] Column packed with Amberlite IR-4B.

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TEXTBOOK ERRORS[1]

III: The Solubility of Gases in Liquids

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Rising temperature is generally[2] said to reduce the solubility of gases in liquids. The facts,[3] however, disagree with any such generalization which is not even true for water, although it summarizes the behavior of many systems.

An increased solubility with rising temperature seems generally to be observed for H_2, N_2, CO, He, and Ne in a variety of organic liquids, such as CCl_4, C_6H_6, $(CH_3)_2CO$, etc. To quote a few high examples: Lannung[4] found the solubility of He to increase by 16.5 per cent in acetone between 15 and 25°C. and by 34 per cent in benzene between 15 and 27°C. For H_2, Horiuti[5] found an increase of 43 per cent in CCl_4 between 0 and 59°C., and Maxted and Moon[6] of 38 per cent in benzene between 0.5 and 40°C. A spectacular increase in solubility has been reported for the inorganic system O_2 gas in liquid SO_2 where Dornte and Ferguson[7] report a 23-fold change between −20 and +30°C.

If the solubility is measured not at constant partial pressure of the gas (Bunsen coefficient) but at constant concentration in the vapor phase (Ostwald coefficient), the increases become even larger and oxygen in organic solvents joins the list of systems for which they are observed.

In case of water, the situation is somewhat less simple. Early measurements as summarized in the "Critical Tables"[8] show several increases, some quite large, of solubility with temperature at 760 mm. Hg. These were not confirmed, however, by more careful work[4, 9] and any increase seemed to be within the experimental uncertainty. Measurements at high pressure have shown, however, that the solubilities of N_2,[10] H_2,[11] and He[12] pass through pronounced minima at about 70, 55, and 30°C., respectively, leaving no doubt that the situation is the same at 760 mm. Hg or below.

Thus, the solubilities of gases in liquids, like other solubilities, may increase or decrease or change sign with temperature.

[1] Suggestions of material suitable for this column are eagerly sought and will be acknowledged. They should be sent with as many details as possible to K. J. M. at the above address.

[2] Since the purpose of this column is to prevent the spread and continuation of errors and not the evaluation of individual texts, the source of the errors discussed will not be cited. The error must occur in at least two independent standard books to be presented.

[3] Most of the examples quoted and many others may be found in Seidel, A., "Solubilities of Inorganic and Metal Organic Compounds," D. Van Nostrand Co., New York, 1940. For a discussion of the thermodynamics, Frank, H. S., and M. W. Evans, *J. Chem. Phys.*, 13, 507 (1945).

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ATOMIC-WEIGHT VARIATIONS IN NATURE

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IT IS customary for textbooks and teachers of general chemistry to emphasize the constancy of the atomic weight of an element regardless of the source from which it is obtained. On closer examination, however, this generalization appears to resemble many of the simple quantitative laws of science—it is valid for experiments up to a certain degree of accuracy of measurement; beyond that point variations are observed. By a study of these variations a more exact description of nature can be achieved, and eventually the variations themselves may prove to have applications undreamed of earlier.

On the basis of Dalton's original atomic theory there was no reason to suspect variations in the atomic weight of an element. All of the atoms of a given element were assumed to be alike in all respects, including weight. Early laboratory work confirmed this expectation, even when chemical methods for determining atomic weights had been vastly refined through the careful techniques introduced by Hönigschmidt, Richards, and others. For example, a number of workers have determined the atomic weight of chlorine, using samples of chlorine from widely different sources. Within experimental error exactly the same atomic weight was found for chlorine from a mineral of known great age (apatite) (*3*), from a rock of nonmarine origin (Wernerite) (*5*), from salt water at a depth of 1573 meters in the Calumet and Hecla mine near Lake Superior (*4*), from volcanic NH_4Cl from an eruption of Mt. Vesuvius (*4*), from a chlorine compound in a meteorite (*5*), and from salt obtained from sea water.

The revolution in physical thought which occurred around the turn of the century brought a clearer understanding of the nature of the atom. The discovery by J. J. Thomson, in 1913, that the atoms of stable elements are not all identical but exist in different isotopic forms having different weights made it clear that the atomic weight of an element depends upon the proportion in which the various isotopes appear in the naturally-occurring mixture. Only if a given element has exactly the same isotopic composition, regardless of the source from which it comes, can it have a constant atomic weight.

TABLE 1
Isotopic Composition of Lead from Different Sources (*7*)

Isotope	*Sample from Pacific Ocean*	*Sample from meteor*
204	1.343%	2.006%
206	25.42%	18.88%
207	21.13%	20.61%
208	52.11%	58.51%

RADIOACTIVE PROCESSES

Elements like lead which are the end products of radioactive decay processes would be expected to have an isotopic composition that depends on the radioactive processes involved in the formation of a given sample. The isotopic composition of a sample of lead obtained from the Pacific Ocean is compared in Table 1 with that of a sample of meteoric lead. On the basis of these isotopic variations, the atomic weight of lead in the two samples would differ by about 0.1 atomic-weight unit.

An extreme example of a situation in which the atomic weight of an element depends on its method of formation is found in the case of the recently produced man-made elements. The element americium, for example, can be prepared by a number of radioactive processes, each leading to a single isotopic species. The reaction:

$$_{93}Np^{237} + {}_{2}\alpha^{4} \rightarrow {}_{95}Am^{239} + 2{}_{0}n^{1}$$

gives americium with an atomic weight of 239, while the process:

$$_{94}Pu^{239} + {}_{2}\alpha^{4} \rightarrow {}_{95}Am^{242} + {}_{1}p^{1}$$

yields americium with an atomic weight of 242. For these elements which do not occur in nature the concept of an average atomic weight is meaningless.

FRACTIONATION PROCESSES

Quite aside from atomic-weight variations that are introduced by the method of origin of elements, there are many natural physical, chemical, and biological processes which continually tend to fractionate uniform mixtures of isotopes. Different isotopes of the same element have different weights, and any process, the rate or equilibrium condition of which depends on the weight of the atoms involved, will tend to separate the original mixture of isotopes.

It is well known that the rate of diffusion of a gas is inversely proportional to the square root of its molecular weight. A light molecule will pass through a small hole, through a porous solid, or through another gas more rapidly than a heavier molecule can. This principle is used in separating uranium isotopes in the atomic-energy program. If the gas UF_6 is allowed to diffuse through a porous barrier, the molecules containing the lighter U^{235} isotope diffuse through the pores more readily than those containing the more abundant

but heavier U^{238} isotope. Diffusion processes are continually at work in nature and would be expected to produce some slight separation of heavier and lighter isotopes.

The rate at which a liquid evaporates is also inversely proportional to the square root of the weight of the molecule, provided the molecules compared are otherwise identical. Brönsted and Hevesy (*1*) allowed part of a sample of pure mercury to evaporate and found that the portion remaining was 1.000031 times as dense as the starting material, while the condensed vapor was only 0.999980 times as dense. Repetition of the process gave much greater isotopic separation, but a measurable separation occurred after only one partial evaporation.

Although the chemical properties of different isotopic forms of an element are nearly identical, they are not exactly so. Consequently, some isotopic fractionation may occur during chemical reactions. As an example, the isotopic exchange reaction:

$$O_2^{16} + 2H_2O^{18} \rightleftarrows O_2^{18} + 2H_2O^{16}$$

would have an equilibrium constant of 1.000 if the two isotopes of oxygen were equally reactive; actually the equilibrium constant is 1.012 at 25°C. and increases still further at lower temperatures. Hydrogen, oxygen, nitrogen, carbon, and sulfur isotopes have all been separated artificially using chemical effects; these same effects are operative in nature to prevent perfectly uniform distribution of isotopes.

OBSERVED VARIATIONS

It is possible, by means of mass spectrometry or other very careful physical measurements, to determine the relative abundance of isotopes with a greater degree of precision than can be obtained in chemical atomic-weight determinations. Unfortunately the weights of the individual isotopes are often not known to the same precision. Even if these individual weights are not known as accurately as the relative abundances, the latter may be used to calculate comparative values for the atomic weight of samples of an element from various sources. Such determinations have been carried out for a number of the elements, and variations in atomic weight have been detected that must be attributed to natural fractionation processes.

Table 2 shows the atomic weight of oxygen obtained from various sources. The lower atomic weight of oxygen in fresh water compared with ocean water is presumably due to the higher volatility of H_2O^{16}. Chemical exchange of oxygen between CO_2 and H_2O favors a concentration of the heavier isotope in the CO_2, so the high values in CO_2 and the carbonate rocks are understandable.

Nier and Gulbransen (*6*) have studied the relative abundance of the carbon isotopes from various sources. They found an average C^{12}/C^{13} ratio of 88.3 ± 0.3 in samples of limestone, 89.5 ± 0.3 in rock samples of igneous origin, and 91.7 ± 0.2 in samples of plant material. These values correspond to a difference of 0.0004 units between the atomic weight of carbon in the samples of limestone and of plant material. The variations are of the magnitude and in the direction that might be expected from consideration of the equilibrium constants of the chemical reactions most likely to have been involved in the formation of the various substances.

Reynolds (*8*) has studied the distribution of the isotopes of silicon in various minerals. A total variation of about three per cent was observed in the Si^{30}/Si^{28} ratio, the heavier isotope being more abundant in marine sediments of organic origin (chert, diatomite), and the lighter isotope more abundant in silica deposited from an aqueous medium (vein quartz, geyserite).

TABLE 2
Atomic Weight of Oxygen from Various Sources (*2*)

Source	*Atomic weight*
Atlantic Ocean water	16.00000[a]
Lake Michigan water	15.99998
Air	16.00012
Carbonate rocks	16.00015
CO_2 (at 0°C. in presence of H_2O)	16.00019

[a] This value is arbitrarily taken as 16.00000 for comparison.

The isotopic composition of the sulfur deposits in Texas and Louisiana has been investigated by Thode (*9*). Native sulfur contains on the average 3.8 per cent less S^{34} than is found in associated sulfate compounds. This has been taken as evidence that the native sulfur deposits were formed by bacterial reduction of the sulfate compounds, a process which is known to be accompanied by an enrichment in the lighter S^{32} isotope. Confirmation of this supposition is found in the fact that limestone from the same deposits is low in C^{13} content, indicating that it is not of the usual sedimentary origin but has been formed from carbon dioxide of organic origin, such as would have been liberated by the sulfur-reducing bacteria.

APPLICATIONS

In addition to providing evidence regarding the mode of formation of mineral deposits, variations in the natural abundance of isotopes have been put to a number of other uses. One of the best known is the determination of the age of the earth and of specific rock samples. C. C. Patterson (*7*) has estimated the age of the earth as 4.6 billion years by comparing the abundance of lead isotopes in meteorities and in the ocean. Lead from the ocean contains a relatively high concentration of lead isotopes resulting from the decay of uranium, the rate of decomposition of which is known. The amount of uranium in meteorities is quite small, so the distribution of lead isotopes there can be taken as an indication of the isotopic distribution at the time when the meteorites and the earth were formed.

Measurements of isotopic abundance have even provided information from which can be deduced the

temperature of the oceans in early geological times. Urey and co-workers (*10*) have found that the isotopic composition of oxygen in calcium carbonate varies with the temperature at which it has been crystallized from solution. The effect is small but measureable; if the water used contains 0.1996 per cent O^{18}, this isotope will be concentrated in the calcium carbonate to 0.2040 per cent if crystallization occurs at 25° C., and to 0.2048 per cent at 0° C. Thus, by measurement of the concentration of O^{18} in a fossil, the temperature at which it was formed can be determined. The method has provided geologists with considerable information regarding temperatures in geological time on different portions of the earth's surface and has even been able to give some information regarding the extent of seasonal variations in temperature. As layers are peeled off a fossil shell, a variation in O^{18} abundance is observed which corresponds to variations in the temperature of the ocean as the shell was being formed in the distant past.

ATOMIC-WEIGHT VARIATIONS

The variation which has been observed in the natural abundance of the isotopes places a limit on the accuracy with which it is possible to know average atomic-weight values. The atomic weight of oxygen has been seen to vary by somewhat more than one part in 100,000. Since other atomic weights are given on the chemical atomic-weight scale by comparison with the average atomic weight of oxygen, the uncertainty of one part in 100,000 will also apply to their values. Some atomic-weight determinations have been made with sufficient precision to approach this limit. Further refinement in the atomic weight of silver (107.880) would be impossible unless the reference value for oxygen were defined more precisely. Various suggestions have been proposed, perhaps the simplest being to use the physical atomic-weight scale on which the weight of O^{16} is defined as exactly 16.

Even with a well defined reference value for atomic weights, a limit to the accuracy with which average atomic-weight values can be known is imposed by the variability of the isotopic composition of the individual elements. For carbon this limit appears to be about ± 0.0002 atomic-weight units. In a general way this variability will be greater for the lighter elements and smaller for elements of greater mass.

The list of atomic weights currently approved by the International Union of Chemistry gives a value of 32.066 ± 0.003 for sulfur because of natural variations in the relative abundance of its isotopes. This is the only element for which the uncertainty due to natural variation is greater than the experimental error of officially accepted determinations.

A limit is also placed on the possible accuracy of quantitative chemical work, since this depends on a knowledge of the atomic weights of the elements used. Unless all of the chemical reactions used go to completion, there will be a fractionation of isotopes owing to a variation of the rates or equilibrium constants of the reactions with different isotopes. Actually, in the determination of natural abundances of isotopes one problem which always presents difficulty is assurance that no separation is being introduced artificially by the chemical and physical processes employed.

Perhaps nature has been kind to the chemist in providing such nearly uniform distributions of isotopes that the atomic weights of the elements may be regarded as constant for ordinary chemical work, yet show small variations which can be used to obtain information regarding the manner of formation of substances and the conditions which prevailed during their formation.

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"The time has arrived when a knowledge of physics and chemistry forms as important a part of education as that of the classics did two centuries ago. In those days the nations which excelled in classical learning stood foremost, just as now the most advanced are those which are superior in the knowledge of the natural sciences, for they form the strength and characteristic of our times."

Mendeleev, "The Principles of Chemistry"

WÖHLER AND THE OVERTHROW OF VITALISM

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McKie[2] has expressed the opinion that the synthesis of urea from ammonium cyanate did not mark the beginning of the demise of the vitalistic theory, and indeed that Wöhler himself still held to vitalism at this time. Such opinions are valuable if they cause the reader or teacher to examine the evidence for himself. However, there is a danger that such "debunking" will be accepted at face value, without critical examination of the evidence. Such is the case here. McKie's opinion has gained credence since it was cited in a popular text,[3] and I have noticed a tendency on the part of some younger instructors and writers to make statements beginning: "It was formerly believed that in 1828 Wöhler synthesized urea from ammonium cyanate, and thus overthrew the vitalistic theory, but...."

I urge every writer and teacher who refers to the vitalistic theory and its breakdown to examine the original statement by Wöhler, and other opinions of the day. Fortunately this is easy to do. In addition to the article by McKie, which cites the original literature, there is an excellent summary of contemporary opinion of Wöhler's discovery by Warren,[4] and best of all, a reprint of the original article[5] accompanied by a translation, available in most chemical libraries.[6]

McKie's objections are matters of interpretation, and may be summarized: (*a*) Synthesis of urea from ammonium chloride and silver cyanate was not a total synthesis from "dead" material, since the cyanate had been obtained from blood or horn; (*b*) Wöhler and his contemporaries did not regard this as a synthesis without the influence of a vital force. Let us examine the evidence which applies to each of the above objections.

(1) It is true that both potassium cyanide and potassium cyanate were prepared commercially at that time from dried blood or horn. However, Wöhler had also prepared potassium cyanate from mercuric cyanide, and from cyanogen. Both of these substances were known to be nonvital (inorganic) at the time, since both Scheele's preparation of potassium cyanide from carbon (1783) and Gay-Lussac's synthesis of cyanogen from mercuric cyanide (1814) were described in a popular textbook.[7] This was then, in fact, a total synthesis from "dead" carbon, since Scheele used both charcoal and graphite as sources of carbon.

(2) Wöhler must have understood the implications of his discovery on the vitalistic theory, since he wrote in the original article:

> ... diese Untersuchung hat das unerwartete Resultat gegeben, dass bei der Vereinigung von Cyansäure mit Ammoniak Harnstoff entsteht, eine auch in sofern merkwürdige Tatsache, als sie ein Beispiel von der künstlichen Erzeugung eines organischen, und zwar sogenannten animalischen, Stoffes aus unorganischen Stoffen darbietet.[8]

To be sure, Wöhler also wrote to Berzelius:

> A natural philosopher might say that the organic part had not disappeared from the animal charcoal or from the cyanogen compounds made from it, and consequently it is always capable of giving rise to an organic body.[2, 4]

McKie believes this statement to mean that Wöhler thought his cyanic acid still retained the vital force, but it seems more likely that by a "natural philosopher" Wöhler meant not himself, but a die-hard vitalist.

Ample evidence that Wöhler's contemporaries also recognized the significance of his discovery is cited by Warren.[4] Of these, two chemists of the first rank should be mentioned. Dumas, in 1830, wrote: "All chemists have applauded the brilliant discovery by Wöhler of the artificial formation of urea." In 1837 Liebig said, "The extraordinary and to some extent inexplicable production of urea *without the assistance of vital functions*, for which we are indebted to Wöhler, must be considered one of the discoveries with which a new era in science has commenced." (Italics mine.)

I submit that the evidence shows that Wöhler was the first clearly to record and comment on the synthesis of an organic substance from materials known to be inorganic, and that the significance of this discovery was noted by important chemists of the time. It is therefore no chemical myth that Wöhler, with his synthesis of urea in 1828, sounded the death-knell of vitalism.

ACKNOWLEDGMENT

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[1] Visiting Professor, on sabbatical leave from Indiana University, 1954–55.

[2] McKie, D., *Nature*, **153**, 608–10 (1944).

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[5] Wöhler, F., *Ann. Physik.*, **12**, 253–7 (1828).

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[7] Berzelius, J. J., translated by K. A. Blode and K. Palmstedt, "Lehrbuch der Chemie," Dresden, **1823**, Vol. I, pp. 606–16; 664.

[8] "... this research has given the unexpected result, that urea is produced by the combining of cyanic acid with ammonia, an especially remarkable fact inasmuch as it offers an example of the artificial production of an organic, and indeed a so-called animal substance from inorganic (nonorganic) materials."

ROBERT JOHN KANE (1809-90): IRISH CHEMIST AND EDUCATOR[1]

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In 1944 a series of meetings was held in Dublin, Ireland, under the general title of the Natural Resources of Ireland. Experts in the fields of fuel, water resources, minerals, fisheries, and forestry reviewed the progress that had been made in Ireland in recent years in the development of these resources. This was a centenary celebration, for 100 years earlier, on June 1, 1844, Robert John Kane, an Irish chemist and far-sighted thinker, published a book, the "Industrial Resources of Ireland," in which, for the first time, a sound scientific and economic case was made for the greater utilization of native Irish reserves.

Kane's memory is therefore still green in Ireland from the aspect of this significant book and of his work in furthering native development. He was also noted as an able university administrator. He deserves recognition among chemists, too, for he was responsible for significant chemical discoveries that won him a European reputation at the comparatively early age of 35.

Kane's interest in chemistry stemmed from his father, who had been known originally as John Kean. John Kean lived in Dublin and was one of the group of Irishmen who were active in the planning of the unsuccessful Irish Rebellion of 1798. This period of unrest forced overseas a number of men who were later to be prominent in American chemistry. Among these were William James MacNeven[2] and the young John Patten Emmet, nephew of the noted Irish patriot Robert Emmet.[3] John Kean fled to France, where he passed his exile studying chemistry in Paris. When things had quieted down he returned to Dublin, changed his name, and began to make chemicals, including saltcake, sulfuric acid, and bleaching powder. He prospered in this venture. There is a traditional belief in the Irish sulfuric acid industry that his plant was the first firm in Great Britain or Ireland to build and operate a Gay-Lussac tower, and that the Kane Company installed a number of such towers in English plants.[4]

Robert John Kane, his second son, was born in Dublin on September 24, 1809. Brought up in the neighborhood of his father's plant, he developed an early interest in chemistry. His first paper, which was polemic in nature, was published in 1828.[5] Kane pointed out in this paper that the view of a rival Dublin acid maker, that mineral manganese dioxide contained chlorine, was incorrect. He pointed out that the chlorine came from hydrochloric acid which contaminated the sulfuric acid used in the tests. The following year Kane described in the same journal[6] the natural arsenide of manganese now known as "Kaneite."

Kane was studying medicine in Dublin when he published these early papers. At that time there were three kinds of medical practitioner in Dublin. First, there were physicians, usually graduates of English and Scottish universities, as Irishmen found it difficult to secure training as physicians at home. Second, there were the surgeons, largely graduates of Trinity College, Dublin (Dublin University). The third group were the licentiates of the Irish Apothecaries' Hall, who both prescribed and dispensed prescription remedies.

In order to strengthen the scientific qualifications of its graduates, the Apothecaries' Hall decided to reorganize its combined professorship of materia medica and chemistry as two separate professorships. Kane, only 22 years old at the time, was a medical student at Trinity College, Dublin. His aptitude in chemistry was apparently already well recognized, and he was offered the chair of chemistry at the Hall, an offer which he readily accepted.

Soon after taking the new post, Kane published his first book, "Elements of Practical Pharmacy." This represented the first attempt made to introduce certain European ideas and methods of teaching the subject into Ireland, and was influenced by a period that Kane had spent studying pharmacy a year earlier in Paris.

Kane, like others in Ireland at the time, was well aware of the fact that there was no Irish journal in which outstanding facts of chemical interest could be recorded, no work which would regularly abstract the scientific papers then appearing in great numbers from Continental laboratories. Accordingly, he founded, at the age of 22, a periodical called the *Dublin Journal of Medical and Chemical Science*.[7] He originally intended this for the publication of solely abstracted material of chemical and pharmaceutical interest. Afterward,

[1] Presented before the Division of the History of Chemistry at the 127th Meeting of the American Chemical Society, Cincinnati, March, 1955.

[2] REILLY, D., *Chymia*, 2, 17–26 (1949).

[3] REILLY, D., "Three Centuries of Irish Chemists," Cork University Press, Ireland, 1941, p. 12.

[4] WHEELER, T. S., *Endeavour*, July, 1945, p. 91.

[5] KANE, R. J., "Observations on the existence of chlorine in the native peroxide of manganese, etc.," *Quart. J. of Sci., Lit., and Art*, 1828 (ii), p. 286.

[6] KANE, R. J., "Chemical examination of a native arseniuret of manganese," *ibid.*, 1829 (ii), p. 381.

[7] This journal continues to the present time, though now purely as a medical periodical, as the *Irish Journal of Medical Science*.

at the insistance of the joint editors Drs. Graves and Stokes, two of Dublin's most notable doctors, the journal also included notes on practical medicine.

Kane was editor of the journal during its first two or three years, and for several years afterward contributed papers to its pages. In its first five years of existence he published ten original papers in its pages. These ranged from the composition of urine and blood in certain pathological states to the structure of the iodides of platinum; from the constitution of the ethers to the compounds of chlorine.[8]

Photo I. T. A.

University College (Formerly Queen's College), Cork, Where Kane was President for Almost 30 Years

In his first paper in the journal[9] Kane showed that the quantity of organic bases present in body fluids in diabetic conditions is not affected by the extent of the disease, an observation which was significant in the development of the modern theory of the disease. Kane's interest in body fluids was already an established one, for as early as 1829 he had received a gold medal from the medical society of the Meath Hospital in Dublin for an essay on the effect of morbid poisons in the circulation. Another essay in the same year, on the pathological condition of the body fluids in typhus fever, had won him a special prize from Dr. Graves, and had stimulated local medical thinking on humoral pathology in line with more recent Continental ideas.

In a paper entitled "Remarks on the properties of the hydracids,"[10] Kane demonstrated the electropositive nature of hydrogen, and questioned many of the older incorrect assumptions regarding the acidic nature of certain compounds containing the hydroxyl radical.

In 1832 Kane was elected a member of the Royal Irish Academy. In June of that year he read a paper to the Academy "On the iodide of platinum and its saline compounds." A month later he published the paper in the *Dublin Journal of Medical and Chemical Science.*[11] During the same year, Lassaigne, the French chemist, was working on the same problem, and announced the discovery of a similar iodide of platinum. The question of priority led to correspondence between the two chemists, and Kane ultimately accepted Lassaigne's precedence in a later paper on the same topic.[12]

On January 1, 1833, Kane published an "Announcement of the theory of a basis (ethereum) combining with hydrogen."[13] Here he outlined a theory regarding the existence of certain radicals which took part in chemical reactions in much the same way as simple atoms. His work dealt with the ethereum (ethyl) radical, and he suggested the similarity between this and the ammonium radical.

Liebig, developing ideas of Dumas and Berzelius, put forward similar views in 1834. In the subsequent dispute Kane had no difficulty in establishing his priority. He has left it on record[14] that when his theory was first put forward, it was "a subject of amusement and ridicule among the chemical circles" of Dublin. Partington has aptly commented that "their sense of humor was evidently better than their sense of judgement."[15]

While at the Apothecaries' Hall, Kane gave a series of public lectures on science. This was probably the first lecture course of its kind attempted in Ireland, and it drew large audiences. In 1834 Kane resigned his Apothecaries' Hall position to become lecturer (and later professor) of natural philosophy at the Royal Dublin Society. Edmund Davy, cousin of Humphry Davy and discoverer of acetylene, was professor of chemistry there at that time. Kane's duties included public lectures on various sciences.

He also worked on the chemistry of the products of wood distillation, and as a result developed his calcium

[8] For a full list of Kane's papers in this journal, see REILLY, "Sir Robert Kane," Cork University Press, Ireland, 1942, p. 18.

[9] KANE, R. J., "On the composition of urine and blood in diabetes mellitus," *Dublin J. Med. Chem. Sci.*, No. I, 1832, Art. 4.

[10] KANE, R. J., *ibid.*, No. III, 1832, Art. 17.

[11] KANE, R. J., *ibid.*, No. III, 1832, Art. 20.

[12] KANE, R. J., *ibid.*, No. IX, 1833, Art. 15.

[13] KANE, R. J., *ibid.*, No. VI, 1832–3, Art. 21.

[14] KANE, R. J., "Notice on the theory of the aethers," *Phil. Mag.*, 14, 165 (1839).

[15] PARTINGTON, J. R., "Short History of Chemistry," London, 1939, p. 233.

chloride process for the separation of pure methyl alcohol from wood spirit. Realizing that Continental methods of organic assay were superior to those at his disposal, Kane spent the summer of 1836 in Liebig's laboratory in Giessen doing portions of his work on methyl alcohol there. The following year he announced[16] that acetone (which he called "mesitic alcohol"), which is a component of wood spirit, yielded when heated with sulfuric acid a hydrocarbon which Kane called "mesitylene." Although its theoretical implications were not fully appreciated at the time, we now know that this reaction involved a passage from a chain to a ring compound and was fundamental in establishing the symmetry of the benzene ring.[17]

An important phase of Kane's chemical work was incorporated into his detailed studies of the compounds which ammonia forms with salts of mercury, copper, zinc, and other metals. The research was everywhere hailed as important. Berzelius, in his annual reports for the year 1837, wrote that in his opinion Kane's researches on the subject were among the most important recorded in that particular year.[18] Kane quickly won a European reputation as a result of this work. Seven years later the Royal Irish Academy awarded him its Cunningham Gold Medal for these researches. The theoretical basis of the investigation that ammonia is an amide of hydrogen, with one hydrogen atom differing from the other two, is no longer of interest, but the work showed much experimental skill.

In 1840 Kane became editor of the *Philosophical Magazine*, and in the same year published a paper on the coloring matter of lichens.[19] This report was a pioneering effort in an extremely difficult field of research. Though the use of vegetable color tests for acid and alkali dates back to Robert Boyle, knowledge of the chemical mechanisms involved had advanced little by Kane's day. The constitution of these substances was hard to unravel, as they decomposed easily, especially on examination, and they were very similar to each other in chemical structure. For this work the Royal Society awarded him its Royal Medal, and nine years later he was elected to Fellowship of the Royal Society.

In 1841 Kane published the first two volumes of his masterly "Elements of Chemistry." The third part followed in 1843. The book consisted of 1204 pages and was illustrated with 236 woodcuts. It included, as Kane stated on the title page, the most recent discoveries and applications of chemical science to medicine and pharmacy and the arts. It was a well written book and soon was a great success, hailed on both sides of the Atlantic as the best printed introduction to chemistry then available. Its 30 chapters included: discussions on gravity; properties of light, heat, and electricity; chemical affinity; heat of reactions; laws of combination; nonmetals and metals; organic compounds; fermentation; essential oils; soaps: distillation; and digestion.

In England the book was introduced into the course at Woolwich by Michael Faraday. Dr. John William Draper issued a "pirated" edition in the United States in 1943 and said that it was "as a textbook, undoubtedly the best extant in the English language." Despite the pirating, Kane received portions of the American receipts from Draper. However, it is not believed to be true—though it has sometimes been asserted—that Kane was paid more on the basis of the pirated edition than he was for the legitimate edition.[20]

Within the present compass, no attempt will be made to discuss Kane's noteworthy "Industrial Resources of Ireland," which he published in 1844, and his subsequent appointment as director of the new Museum of Economic Geology. Kane soon afterward was knighted for his service to science and Irish industry.

When potato blight first appeared in the fall of 1845, Kane was a member of a three-man scientific commission set up to inquire into the nature of the disease. The problem was beyond the scientific resources of the time, and the commission achieved nothing.

Kane spent almost 30 years as first president of Queen's College (now University College), Cork, Ireland. Here he won a high reputation as an administrator,[21] but did not interest himself further in chemistry. He held a number of honorary offices in his native Dublin following his retirement from the Cork presidency in 1873, and was connected with the administration of various colleges and educational programs. He died in Dublin on February 16, 1890.

Apart from the Draper publication of his textbook, another link between Kane and the United States was in the person of Dr. Thomas Antisell (1817–93). Antisell was an Irish medical man and scientist who had studied chemistry in Dublin under Kane. He became involved in the rebellion of the "Young Irelanders" in 1848 and fled to the United States. He won a high reputation as a chemical lecturer and author, geologist, and scientific examiner in the U. S. Patent Office in his later years.[22]

[16] KANE, R. J., "Research on the combinations derived from pyroacetic spirit," *Proc. Roy. Irish Acad.*, **1837**, I, 42.

[17] WHEELER, T. S., *loc. cit.*, p. 92.

[18] WÖHLER, F., *Jahr. über die Fortschr. der physis. Wiss., Tübingen, 1838*, **17**, 179.

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[20] REILLY, D., "Sir Robert Kane," Cork University Press, Ireland, **1942**, p. 17.

[21] WHEELER, T. S., *Cork University Record*, No. 3, **1945**, pp. 29, 38.

[22] REILLY, D., *Amer.-Irish Hist. Soc. Recorder*, **16**, 26–9 (1954)

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TECHNICAL WRITING IN INDUSTRY AND EDUCATION

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Not long ago the placement office at Rensselaer Polytechnic Institute called the English department about one of the students in the graduate program in technical writing. A request for an interview had come in from one of the large chemical companies. Later the company interviewer confessed to the student that he had been prompted largely by curiosity. "I've never seen one of your strange breed before," he said. "To me, you are incredible!"

The "strange breed" the interviewer was referring to is that new class of student who is being directly trained for the profession of technical writing. The interviewer was amazed to learn that the colleges are finally starting to produce engineers and scientists whose first interest is in technical writing.

The present demand for technical writers has not always been so widespread. Before World War II few companies found it profitable to hire a full-time writer. What little writing was required was done either by technical personnel or by temporarily hired consultants. Too often the writer was trained solely in the literary art and had little idea of what he was writing about, or else he was called upon to act as proofreader for a paper prepared by a scientist with negligible skill in English composition. The work of either individual usually left much to be desired.

Starting about 1939 the rate at which the government issued contracts to industry was stepped up enormously. Today government contracts account for as much as 70 per cent of the total business of many medium-sized companies. Because of these contracts, the volume of progress reports, correspondence, and interplant communications has expanded tremendously. The result has been that since 1945 industry has attempted more and more to employ professional writers with scientific backgrounds in order to take the load of product explanation off the already overburdened engineers.

The Sperry Gyroscope Company, for example, has established a publications engineering department. Here some hundred people are employed in preparing instruction manuals, technical reports, and brochures of company information designed for quick reading. Deeply aware of their vital function, Sperry management has titled these people *publications engineers;* they are on the same professional level with other engineers.

In other companies, such as General Electric, there are training programs to teach writing techniques to engineers. In some organizations the problems of communication have become so acute that outside experts are being hired to lecture to technical personnel. A good proportion of the time of a personnel man in the Shawinigan Resins Corporation of Springfield, Massachusetts, is taken up with engineer-writers.

Lest there remain any doubt as to the existence of a serious communications problem, one has only to listen to a few complaints from industry. One prominent executive of a major chemical concern has summarized his report troubles: His engineers, he claims, do not always show regard for the written word. Even if they can write well, they frequently do not want to write. Writing is not their first concern, and as a result they are slapdash. Reports are much too wordy. Words important to the sense of a sentence are all too frequently buried in long phrases.

Since many engineering reports are destined for the rapid scrutiny of a busy vice-president, economy of words and clearness of meaning are extremely important. Obviously, the executive who has to spend three hours figuring out exactly what one of his engineers is trying to get across, when the idea could be clearly expressed in a few sentences, is not going to think very highly of that man's ability in any capacity.

Time wasted reading an obscure report is not the least of an executive's troubles. Excessively long bulletins are a direct drain on the company's pocketbook. Printers charge anywhere from nine to 12 dollars per page for copy partially consisting of chemical formulas and mathematical symbols. The cost is high even for moderately technical material with no formulas and symbols: around six to seven dollars per printed page. Unnecessary illustrations, of course, add greatly to the cost of printing. Spurred on by this practical aspect of the communications problem, many companies have begun exhaustive studies into the status of industrial writing.

Recently a technical writing survey was conducted among a random sampling of 200 American industrial concerns. Forty-six per cent of those interviewed indicated that they now employed either a full- or part-time editor. Thirteen companies not now employing an editor stated that they planned to hire one in the near future; they were having too many complaints about the readability of their technical reports. Some companies wrote rather revealing letters: "Your recent request for information strikes a subject close to our hearts. Here. . .our need for technical writers is constantly increasing and our search never-ending." Or, for example, "I feel so strongly on the subject that

for years I have stated that the best course in chemistry that any chemist or engineer may take is more English."

Of the companies hiring full-time editors, all indicated a remarkable minimum of routine in editorial responsibility. Thus, for example, a typical day in the life of an industrial editor might consist of revising reports, writing reports from supplied data, doing library research, abstracting reports, writing speeches and movie scripts, and conducting a course in writing for engineers. Incidentally, educators concede that it is much easier to teach an engineer to write than it is to teach the graduate of a journalism course the necessary engineering to qualify him for technical writing.

Professional recognition is at last starting to come to technical writers. Technical writers are beginning to coordinate their activities. The Society of Technical Writers, founded in Boston, has almost 500 members in 23 states. Regional meetings, where individual writing problems are discussed and evaluated, have been successful in acquainting uninitiated businessmen with the new profession.

In New York two groups are particularly active: the Association of Technical Writers and Editors, and the Society of Technical Writers and Editors. On the west coast the Technical Publishing Society is well established. There are other groups, but perhaps none so closely allied with technical writing in industry as these four. Out of their efforts will undoubtedly emerge a strong national organization dedicated to raising the profession of technical writing to the level of other professions.

Interest in technical writing is not confined to the United States. In London the Technical Publications Association boasts a membership of almost 200. The purpose of the association is: "to promote the advancement of technical publication techniques by the interchange of ideas and to ensure a recognized status for those engaged in publications production."

One might ask what the American universities are doing—if anything—to meet the demand for technical writers. A number of institutions have had technical writing courses, but it is doubtful that these have been of professional caliber. In general, colleges have been rather slow to realize the need for training engineers to write for specific industrial situations.

On June 8, 1953, the first Technical Writers' Institute opened at Rensselaer Polytechnic Institute with 38 company representatives in attendance. These men came from top industry: International Business Machines, Allen B. DuMont Laboratories, General Electric, New York Telephone, United States Rubber, Chance Vought Aircraft, Eastman Kodak, and many others.

The object of this first institute was to bring to delegates a fuller awareness of the entire field of technical writing, to develop greater skill and assurance on the part of the company representatives, and to furnish them with new perspective on their own capabilities.

Conducting the institute were members of the English department of R.P.I.; many of these professors of English have had long careers in teaching technical writing and in most cases have had editing experience. But well aware that direct contact had to be maintained with industry, the Technical Writers' Institute augmented its regular staff with well known lecturers from the companies themselves.

The 1955 institute is the successful result of that first season. The institute plan calls for lectures, panel discussions, laboratory exercises in writing, and personal conferences between company representatives and English department staff. Some of the outside lecturers of this and past seasons have been Gilbert E. Smith, Jr., head of technical publications at General Electric; Elmer T. Ebersol, Jr., associate editor of *Product Engineering;* Robert T. Hamlett, publications manager, Sperry Gyroscope Company; H. C. McDaniel, technical publicity, Westinghouse; and P. R. Heinmiller, managing editor, *General Electric Review.*

At about the same time that the first Technical Writers' Institute was being organized, Professors Chris Sanford and Sterling Olmsted of the English department at R.P.I. decided to attack the industrial writing problem from a different angle. They realized that a graduate program in technical writing should offer not only competence in a skill; the program should provide a solid foundation in theory with an application to various types of problem. A graduate curriculum was drawn up, designed to furnish the man already possessing a technical degree with the additional training which would qualify him for a position as an industrial writer. Thus was the genesis of the master of science degree in technical writing at R.P.I.

Writing and Editing is one of the mainstays of the curriculum. In this course students develop flexibility in style together with an ability to produce a fast, high-quality output of copy. A typical assignment, for example, might be to edit an already-published article so as to make it suitable for a different type of journal. Thus, a paper on colloid chemistry published by the American Chemical Society might be edited for *Scientific American.*

Advanced Exposition differs from *Writing and Editing* in that there is less pressure to produce and more emphasis on a finished, polished work. Various literary styles and organizations are closely scrutinized and criticized in seminar discussion. In this way the student is encouraged to develop a style appropriate to a given writing problem, regardless of the amount of technicality inherent in the problem.

Writing for Publication naturally follows *Advanced Exposition.* At this stage the student is considered ready to try his hand at actually writing for a specific publication. Papers of various types, both technical and nontechnical in nature, are mailed to appropriate journals around the country.

There are other courses in the curriculum, *Scientific Masterpieces* and *Mechanics of Publishing* among

them. In addition the student is required to carry on graduate study in one or more of the scientific or engineering departments. In general, the curriculum is aimed at satisfying two demands of industry: technical journalism, and manual and report writing.

In regard to technical journalism, a few statements may be in order. At least 2000 journals devoted to technical or industrial information are released periodically in this country by independent publishers. Another 1500 periodicals are published by industry itself (the so-called "house organs," sales reports, research data, etc.). These publications must be written by people who know what they are talking about; *i. e.*, people with scientific training and experience.

Then there are the numerous advertising agencies which have been trying for years to locate engineers with a flair for writing. The agencies have all but given up trying to convince the undergraduate candidate for a degree in science or engineering that he should concentrate on developing writing ability. As one discouraged envoy from industry has said: "Engineers as a class are not interested in writing." Educators agree that time is a potent factor in learning how to write. In the past, industry has been reluctant to devote company time to training engineers in English composition. On the other hand, today the communications problem has become so severe that industry can no longer afford to ignore inferior writing.

The master of science program in technical writing at Rensselaer has this year sent out its first graduates. Other institutions will no doubt initiate similar courses of instruction. But much remains to be done. Colleges in engineering and science should examine their curricula to see what can be done in technical writing early in the undergraduate program. Qualified scientists and engineers must be encouraged through a solid training to embark on the relatively new career of industrial writing.

A MNEMONIC FOR THE MONOSACCHARIDES

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THE appearance of a mnemonic for aldoses,[2] prompts the publication in a modified form of a similar aid, devised by the author some years ago, and put forward by him in a student journal.[3] All references in what follows are to the D series.

The mnemonic is in the form of a table showing the positions of the hydroxyl groups on the 2, 3, 4, and 5 carbon atoms of the chain. The table is begun by writing the names of the four pentoses in alphabetical order, and fitting the tetroses and hexoses to them. For the hexoses, each pair of epimers is written in alphabetical order, *e. g.*, galactose before talose. The positions of the hydroxyls are then put in (*R*ight or *L*eft). For the 5, 4, and 3 atoms we thus obtain *RRRR*, *RLRL*, *LLRR*, three easily-remembered progressions. (In the case of the tetroses, column 3 is rejected.) The situation at the 2-atom is somewhat different, for it is the configuration here that determines which of the epimeric pair the hexose will be. It can be seen that the (alphabetically) first member of each pair is *R*, the second *L*. The α and β forms (carbon number 1) can also be included on this alphabetical principle; α is *R*, β is *L*. Thus the formula of, say, β-glucose emerges from the table as *RRLRL*.

Methylpentoses fit into this scheme if their relationships to the hexoses can be remembered. Rhamnose is mannomethylose, giving for the hydroxyl positions *RRLL*. The same applies to the ketoses. If fructose is recalled as glucoketohexose, its configuration can be deduced.

The table is easily learned, and can be reproduced in less than one minute. It might be argued that it is more useful for the student to deduce these configurations logically from the glyceraldehydes on the basis of the interrelationships between the compounds. Unfortunately it is not possible so to deduce the *names;* and this is where a mnemonic finds its justification.

ACKNOWLEDGMENT

The author is grateful to Professor J. E. Driver for his help in the preparation of this paper.

Tetroses	*Pentoses*	*Hexoses*	5	4	3	2
Erythrose	Arabinose	Glucose—Mannose	*R*	*R*	*L*	*R-L*
	Lyxose	Galactose—Talose	*R*	*L*	*L*	*R-L*
Threose	Ribose	Allose–Altrose	*R*	*R*	*R*	*R-L*
	Xylose	Gulose—Idose	*R*	*L*	*R*	*R-L*

[1] Present address: The University, Nedlands, Western Australia.

[2] DELOACH, W. S., AND A. BRANDON, J. CHEM. EDUC., **32**, 136 (1955).

[3] LEARY, R. H., *Scope*, **3**, 26 (1948).

DETERMINING INTERFACIAL TENSIONS WITH THE DONNAN PIPET

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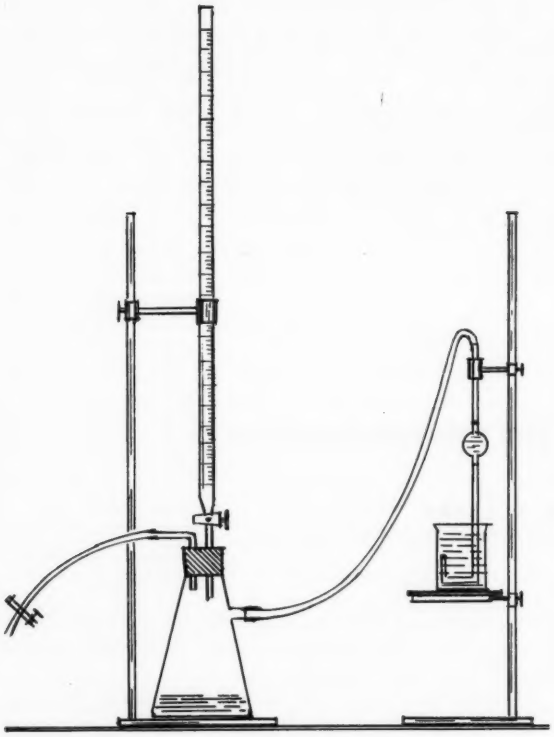

Figure 1

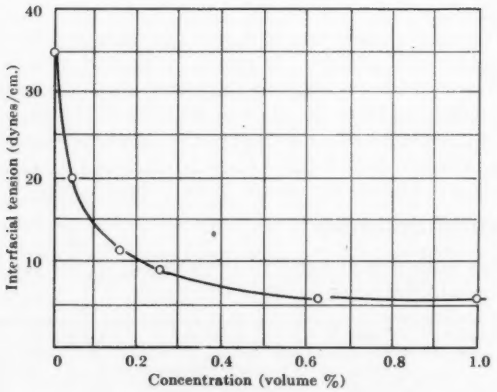

Figure 2

In addition to the usual experiment on surface tension of liquids and liquid mixtures by the capillary-rise method, the student is also required to perform an interfacial-tension experiment. This determination measures the lowering of interfacial tensions of aqueous solutions containing varying amounts of surface-acting agents, using benzene as a reference liquid. The data derived enable the student more fully to appreciate the Gibbs equation on surface activity. This point of view is of particular importance to the mineral engineer for it relates directly to many flotation problems, stabilization of froths and foams, lubrication, and general behavior of many disperse systems.

The success and reliability of this method depends to a large extent on close control of the rate of flow of drops from the tip of the Donnan pipet. The control assembly, simple and requiring no special equipment, has been used with the pipet for many years. (See Figure 1.)

The Donnan pipet is connected by a rubber tube to the side arm of a regular suction flask. A buret and a right-angle glass tube fit into a two-hole rubber stopper inserted into the mouth of the suction flask. A rubber tube with a screw clamp is attached to the outer end of the right-angle glass tube. All connections are air tight.

A liquid, such as benzene, is drawn into the pipet from a 100-ml. beaker supported on a ring stand. To keep the benzene in the pipet, the screw clamp is tightly closed. Water is now started to flow dropwise into the suction flask. The original beaker containing the benzene is rapidly exchanged for 100-ml. beakers containing first pure water, and then various concentrations of detergent solutions. All beakers are exchanged through the ring from the bottom up and supported by the pad

Sample →	*No. of drops* 1	2	3	*Av. no. of drops*	*"γ," dynes/cm.*
Water	21	21	21	21	35.0[b]
0.01% D[a]	26	26	26	26	28.3
0.05%	37	37	37	36	19.9
0.15%	65	68	67	66	11.2
0.25%	95	95	95	95	7.7
0.625%	140	134	136	135	5.5
1.00%	141	144	143	143	5.1

[a] Commercial detergent.
[b] Surface tension at the interface between benzene and water at 20°C.

resting on the ring. This procedure keeps the Donnan pipet at a definite liquid depth for all tests. The rate of benzene droplets can be accurately and evenly controlled.

A typical set of student data is given in the table. The data illustrate the consistency of trial runs on the various solutions. Employing the benzene-water reference value, interfacial tensions of the various solutions can readily be calculated. Figure 2 graphically illustrates such data.

This simple control method has proved to be very efficient in our laboratory and has eliminated many difficulties previously encountered by various clamp control devices.

PROPORTIONAL DIVIDER FOR RAPID DETERMINATION OF CHROMATOGRAPHIC R_f VALUES

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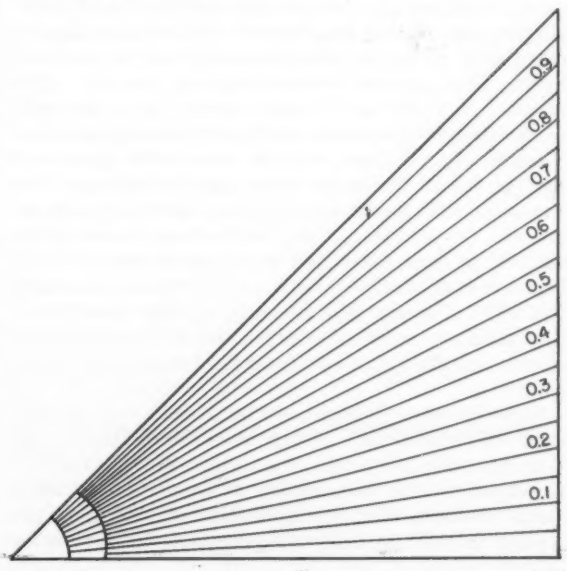
A SIMPLE device is described for rapid determination of chromatographic Rf values. Its combined ease of construction, simplicity of use, and ruggedness offer advantages over related devices previously described.[1] These qualities also make it desirable for student use in experiments on chromatographic procedures.

The device consists of a single piece of $^1/_{16}$-inch transparent, colorless plastic material, such as methyl methacrylate polymer, in the form of a right triangle as illustrated. Twenty lines are inscribed on this from one acute angle to points on the opposite edge which are spaced apart by five per cent of the length of the edge. Indicia are inscribed along this same edge. The edges forming the right angle may be of the same or different lengths; however, the scale side must be longer than the distance from the original spot on the chromatogram to the final solvent front. The inscribed lines show clearly and may be used as formed, or they may be filled with a pigmented material.

In use, the device is placed over the strip or two-way chromatogram with its base (nonscale side) on a line through the original spot parallel to the bottom edge of the paper. The triangle is then moved sideways until its hypotenuse intersects the solvent front at a point directly above the spot being measured. (The right triangle may also be used to erect a perpendicular at this point.) The Rf value of the selected point on the chromatogrammed spot to be determined is read to the nearest 0.05 and estimated to 0.01. The Rf value of the spot in a second solvent is similarly determined.

The device may also be readily used to determine Rx, where distance of travel of a known substance is used as a reference instead of distance to the solvent front. Here a line to replace the solvent front is drawn through the selected point on the reference spot parallel to the base line. If the unknown has traveled further than the reference material, the line is drawn through the chosen point on the unknown spot. The ratio of reference spot to unknown is determined, and the reciprocal is taken.



[1] PHILLIPS, D. M. P., *Nature*, **162**, 29 (1948); ROCKLAND, L. B., AND M. S. DUNN, *Science*, **111**, 332 (1950); NETTLETON, R. M., AND R. B. MEFFERD, *Anal. Chem.*, **24**, 1687 (1952); GLAZKO, A. J., AND W. A. DILL, *ibid.*, **25**, 1782 (1953).

THE CHEMICAL AND RELATED LITERATURE OF SPAIN[1]

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OF THE world's chemical documentation, Spain's contribution is relatively small. This may be augmented by the literature of other Spanish-language countries. However, this paper deals only with the chemical and related scientific literature originating in Spain and her colonies.

In Spain, printed chemical information was disseminated under the headings of pharmacy, medicine, and others, a long time before the appearance of modern chemical literature. To classify Spanish chemical and related literature as among either the world's oldest or youngest documentation depends on whether or not one takes the appearance of the *Anales de la real sociedad española de física y química*, in 1903, as the beginning of chemical literature in Spain, or the start of the *Anales del real laboratorio de química* of Proust, in 1791.

HISTORICAL DEVELOPMENT

There has been a fair continuity in scientific activities in Spain since the time of the Roman Empire when Romanized Spaniards, such as Seneca, Martial, and Lucan achieved literary distinction. Seneca's "Questionum Naturalium Libri Septem" is replete with scientific understanding (*1*). The writings of St. Isidore, Archbishop of Sevilla, contain much of the physical philosophy of the time after the decline of the Roman Empire and during the interim between the Roman occupation of the Iberian peninsula and its conquest by the Moors in the seventh century A.D. (*2*). The mixture of Arabic and Spanish culture from the tenth to the thirteenth centuries had great bearing on scientific activities. These were the years when Spain was the mentor of European science and medicine. The Arabs founded a school in Córdoba that was most renowned for centuries. In Toledo some Arabic texts on alchemy were translated into Spanish; such versions began to appear about 1140 A.D. (*3*). Spain also shares the honor of having developed some of the oldest scientific institutions, for the universities at Valencia, Barcelona, and Zaragoza date from the fourteenth century (*4*).

Some Spanish-Arabic writers possessed a rudimentary chemical knowledge. There was Abū-l-Quāsim al-Zahrāwī, called Albucasis, who died in 1013 in Córdoba. He described the preparation of chemicals including drugs, recommended the distillation of vinegar to get a purer product, and improved methods for distillation (*5*, *6*). The Spanish-born Ibn al-Baitār (1197–1248) compiled the most comprehensive list of drugs of his time (*Kitāb al jāmi* or "Book of Simple Drugs") (*5*). The Spaniard Abû Marvan Ibn Zuhr, called Avenzoar (about 1092–1162), described the preparation of medicines in a treatise called *Al-taisir*. (*5*). A Catalan author, philosopher, mathematician, Ramon Lull (1235–1315) was a chemist at a time when belief in alchemy was common. He is credited with the extraction of potash from vegetable ash, and he devised an apparatus for detecting carbon dioxide in the analysis of organic material (*1*).

With the end of Arabic rule in 1492, the era of the Catholic kings of Spain began. This did not interrupt scientific activities. A pharmaceutical treatise was written by Pedro Benedicto Mateo in 1497, printed in 1521 (*7*, *8*). In the seventeenth century, Gerónimo de la Fuente Pierola wrote "Tyrocinio pharmacopeo médico y chimico" (*9*). Earlier, in 1511, the first "official" pharmacopoeia appeared (*10*), but for more than 200 years, the Spanish pharmacopoeias were college produced. The first "Farmacopea Hispana," the precursor of the present "Farmacopea Española," did not appear before 1794. "Palestra farmaceutico químico galenica" was written by Felix Palacios in the eighteenth century. It is considered outstanding and went through seven editions (*11*).

Foreign scholars were first invited to Spain on the initiative of King Philip V in the earlier part of the eighteenth century. Joseph Louis Proust (1754–1826), one of the great chemists of all times, came to Spain at the end of that century. His contributions include the law of definite and constant proportions in chemical reactions. For a time he taught chemistry at the University of Salamanca and became director of the Royal Laboratory in Madrid in 1789 (*12–14*). While in Spain he published the *Anales del real laboratorio de química* (1791) and was coeditor of the *Anales de ciencias naturales* (1799) (*4*).

An important chemist of Spanish origin of the late eighteenth century was Antonio de Marti y Franquéz, who carried on Lavoisier's work on the composition of air (*14*). Interestingly, three chemical elements were discovered in Spain in the same century: platinum by Antonio de Ulloa (*4*, *15*); tungsten (wolfram) by d'Elhuyar brothers (*4*, *16*); vanadium by Andres Manuel del Río (*4*, *17*).

Several books of interest to pharmacy and chemistry were written in the nineteenth century, such as the

[1] Presented at the 127th Meeting of the American Chemical Society, Cincinnati, March, 1955.

"Diccionario elemental de farmacia" by Hernandez de Gregorio and the "Tratado de farmacia práctica" by Sadaba (*5*).

A decline of science went along with the political decline of Spain in the nineteenth century owing to wars, civil war, and unrest. With the restoration of the Bourbons as kings of Spain in 1874, a period of relative stabilization returned which lasted until the outbreak of the civil war in 1937. In spite of these adverse conditions, the nineteenth and the beginning of the twentieth centuries saw the first appearance of several important journals.

The development of a modern chemical industry in Spain occurred during the turbulent period from the departure of King Alfonso XIII (1931) to the end of the civil war. A number of chemical and related periodicals appeared, and modernization of educational and training facilities for chemists and other scientists began. All this increased the importance of Spanish chemistry and literature.

SCIENTIFIC INSTITUTIONS, PROFESSIONAL SOCIETIES, UNIVERSITIES

The Spanish academies of science, literature, and art were suppressed by the republican government at the beginning of the civil war. They were reorganized and the title "Real" was restored to them in 1939 in recognition of their historical origin. They were incorporated with the Instituto de España, forming a "Senado de la cultura española" (*18*).

Academies. Real Academia Española, Madrid, was founded in 1713; its charter was granted by Philip V. In order of precedence it is now the first among Spanish academies. Real Academia de Ciencias Exactas, Físicas y Naturales, Madrid, was founded in 1847. Real Academia de Farmacia, Madrid, which was founded 1589 as Congregación de San Lucas, became the Real Colegio de Farmaceuticos in 1737 and the Academia de Farmacia in 1931. Real Academia Nacional de Medicina, Madrid, founded in 1732, publishes *Anales* and *Biblioteca Clásica de la Medicina Española* (16 volumes) (*5*, *18*).

Research Councils, Scientific Institutes, Learned Societies. By far the most important scientific body of present Spain is the Consejo Superior de Investigaciónes Científicas. Established by the Law of November 24, 1939, and situated in Madrid, it is a scientific "superagency," consisting of eight "patronatos," or departments, usually named after a noted Spanish scientist and covering various branches of knowledge. It has a library of one million volumes and publishes a considerable amount of literature. Research in chemistry, mathematics, and physics is concentrated in the patronato "Alfonso el Sabio," which maintains the Instituto "Alonsa Barba" de Química.

Following the founding of the Consejo, government expenditures for research expanded greatly. Thus, one hundred four million pesetas were spent in 1952; only three million pesetas were spent for research purposes in 1935. Workers connected with the Consejo have so far published around 1400 papers in all fields of knowledge; in 1953 the Consejo and its various subdivisions published 121 scientific periodicals (*19*).

The Instituto Químico de Sárria, Barcelona, was founded in 1916. It is dedicated to the training of industrial chemists and publishes *Afinidad*, an important Spanish chemical periodical (*18*).

The Asociación Española para el Progreso de las Ciencias, Madrid, was founded in 1908; it publishes *Las Ciencias* and *Tomas de los Congresos*. The Asociación Nacional de Químicos de España, Madrid, was founded in 1945 and has at present 2044 members; together with the older Real Sociedad Española de Física y Química, which resembles the American Chemical Society, they well represent the chemistry of Spain (*18*). The Real Sociedad was founded in January, 1903; its first meeting took place March 22 of that year (*20*). It publishes the *Anales de la real sociedad española de física y química*, still the leading and most important Spanish chemical periodical. In addition to these, there are various medical and other professional societies (*18*).

Universities. In Spain there are some 15 universities controlled by the state, and a few private schools. Among the oldest institutions of higher learning in the world are the universities at Madrid and Barcelona. The University of Barcelona was founded in 1450. Chemistry is part of the Faculty of Science. There is also a School of Pharmacy with facilities for chemical education, and a School of Medicine. The University of Madrid, the most important of Spanish universities, was founded in 1508. Its library is considerably older than the university itself. The library, founded in 1341, now houses 408,000 volumes and 208,000 pamphlets. In the University itself all fields of chemistry are represented (*18*).

The University of Granada was chartered in 1531; at present the number of students is about 3500, while the faculty has 270 members. Chemistry is taught within the Faculties of Science, Pharmacy, and Medicine (*18*).

Of the Spanish universities, the University of Valladolid is the oldest—founded in 1346. It has no School of Pharmacy, but the various fields of chemistry are represented in the curriculums of this school. At present there are about 3600 students (*18*).

The Industrial University of Barcelona is a state technical university (*18*). As of 1953 there were 10 medical schools in Spain. Those of the University of Madrid and University of Barcelona are the largest. Thirty-six hundred medical students attend the former; 1300 students the latter (*21*).

THE CHEMICAL AND RELATED LITERATURE OF SPAIN

As noted earlier, the Spanish chemical literature is only little recognized. Crane and Patterson mention one journal of Spanish origin in their "Guide to the Literature of Chemistry" (*22*). According to them, the number of abstracts handled by *Chemical Abstracts*

from Spanish sources (exclusive of Latin America) was 34 in 1913 and 72 in 1923, as compared to 3940 and 6014 for the U. S., and 6539 and 5064 for Germany. Boig and Howerton, examining the organic sections of the German *Chemische Zentralblatt* and *Chemical Abstracts*, found that 14 organic articles from the *Anales real sociedad física y química* were abstracted in 1948, compared to 848 from *Journal of the American Chemical Society* (*23*). In 1949 Spain held thirteenth place with respect to the number of organic abstracts, and tenth place with abstracts of analytical articles (*24*).

Chemical and related literature of Spain is covered regularly by the important abstracting services such as *Chemical Abstracts*, *Chemische Zentralblatt*, *Biological Abstracts*, etc. In 1951 *Chemical Abstracts* (*26*) reviewed around 50 chemical and related periodicals from Spain, the *Chemische Zentralblatt* abstracted more than 20 in 1952 (*27*), and *Biological Abstracts* surveyed 36 Spanish periodicals out of a total world coverage of approximately 1900 periodicals (*25*). Leading libraries of the United States list a changing number of chemical and related periodicals and other literature of Spain.

Periodicals

Chemical, Physical, and Chemical Engineering Journals. *Afinidad*, primarily concerned with problems of industrial chemistry, is published by the Asociación de químicos del instituto químico de Sarriá, Barcelona. It appears bimonthly and was started in 1923. It has abstracts covering industrial and pharmaceutical chemistry (*26*, *33*). *Anales de la asociación española para el progreso de las ciencias* is the equivalent of the American *Science* and was founded in 1935; it now appears quarterly with general scientific articles (*26*). *Anales de la real sociedad española de física y química* (*Madrid*), formerly known as *Anales de física y química*, consists of two monthly series: Series A, *Fiscica*, and Series B, *Química*. Both are published by the Real Sociedad Española de Física y Química. This journal has appeared since 1903, but was interrupted for one year during the civil war. It usually has English summaries of the Spanish articles on all fields of chemistry and physics, according to the series. *Euclides* (*Madrid*). *Revista mensual de ciencias exactas, físicas, químicas, naturales y aplicaciónes técnicas* is an interesting journal with a variety of articles in Spanish or English. It appears monthly and was started in 1904. *Ion revista española de química aplicada* has appeared monthly in Madrid since 1940. The articles concern industrial chemistry, instrumentation, and pharmacy. *Nucleo* (*Madrid*). *La ciencia y la técnica en la era atomica* is a continuation of *Nueva industria química*. It has appeared monthly since 1945. *Publicaciones del instituto de química "Alonso Barba"* (*Madrid*) appeared first in 1946. It is published annually by the Consejo superior de investigaciónes científicas. *Revista de la real academia de ciencias exactas, físicas y naturales de Madrid* has changed names several times; it appears quarterly. *Revista de ciencia aplicada* (*Madrid*). *Publicada por el patronato "Juan de la Cierva" de investigación técnica* is another publication of the Consejo superior de investigaciones científicas. Since 1946 it has appeared bimonthly bringing articles on various fields of chemistry (*26*).

Pharmacy. Paralleling the illustrious history and importance of pharmacy in Spain is a relatively large number of pharmaceutical periodicals. These are among the oldest of Spanish scientific publications. Of particular interest are the following three: *Farmacia española* (*Madrid*), appearing since 1869, and published weekly (*28*). *Anales de la real academia de farmacia*, a bimonthly published in Madrid since 1934, often including papers on medicinal chemistry. *El Monitor de la farmacia y de la terapéutica* (*Madrid*), a bimonthly, has appeared since 1895 (*26*, *28*).

Pharmacology, etc. *Farmacoterapia actual. Revista científica de farmacología y técnica químicofarmaceutica* (*Madrid*) was edited by Professor B. L. Velázquez of the University of Madrid. It appeared first in July, 1944, was suspended after the March, 1950, issue, reappeared shortly in 1952, only to disappear again. Its present fate is obscure (*29*). *Anales del instituto de farmacología española* (*Madrid*) is a collection of pertinent articles in book form; Volume II appeared in 1953. *Archivos del instituto de farmacología experimental* (*Medicina*) (*Madrid*) is published by the Consejo superior. It appears semiannually (*26*). *Farmacognosia* (*Madrid*), the only pharmacognostic periodical in Spain, has appeared three times a year since 1950. *Revista española del fisiología* (*Barcelona*), an important journal dedicated to basic physiology, has been distributed quarterly since 1944 with English summaries. *Trabajos del instituto "Santiago Ramón y Cajal" de investigaciónes biológicas* (*Madrid*) is a quarterly; separate sections on physiology, fermentation, virology, and biological chemistry appear irregularly. This is another of the important publications of the Consejo superior but with a unique history. As *Revista trimestral micrográfica*, it was founded at the beginning of the nineteenth century by S. Ramón y Cajal, a Nobel laureate in 1906 for his discoveries on the histology of the nervous system.

Medicine. *Actualidad médica. Revista mensual* (*Granada*), a monthly clinical journal, is 30 years old and is published by La Asociación de prensa médica española. *Bulletin of the Institute for Medical Research*, published quarterly in English by the Instituto de Investigaciónes Médicas of the Consejo superior, was introduced in 1947 to make Spanish medical literature more accessible to foreign investigators. As a rule, everything published in the *Bulletin* appears in Spanish, usually in the *Revista clinica española*, which appears semiannually in the form of four volumes (*26*).

Pharmacopoeia, Indexes, Bibliographies, Abstract Services, Monographs

The present version of the pharmacopoeia of Spain known as "Farmacopea Oficial Española," had its eighth edition published in Madrid in 1930 (*30*). As

for chemical indexes, one written by Serrallach is important. It contains much useful information on Spanish and other chemical and related literature; written in Spanish, the emphasis is on non-Spanish literature (*31*). No general chemical abstracting services exist in Spain. Several chemical and related periodicals list abstracts but only to a limited extent: *Anales de la real sociedad española de física y química*, *Dyna*, *Euclides*, and *Ion*. Limited medical abstracting services are provided by *Acta ginecológica*, *Analecta terapéutica*, *Angiologia*, *Bulletin of the Institute of Medical Research*, among others. Chemical treatises are few. Two of them are "Química general, aplicada a la industrual, con prácticas de laboratorio" (E. Calvet, Salvat Editores, S.A., 1945–52) covering inorganic and organic chemistry, and "Métodos de trabajo en la química de los carbons" by Gómez Aranda & Gonzalez Sáncher, in two volumes, and published by the Consejo superior (*32*). Chemical textbooks are numerous and Karrer's well known text "Organic Chemistry" is available in the form of a Spanish translation (*33*).

Encyclopedias and Dictionaries

General encyclopedias of excellent quality and extensive coverage are published in Spain. The "Enciclopedia universal ilustrada Europeo-americana," often cited as "Espasa," with more than 80 volumes, is published by Espasa-Calpe, S.A., Madrid. It is one of the most comprehensive encyclopedias written (*34*). The "Diccionario hispánico universal, enciclopedia ilustrada en lengua española" (Editoriales Exito, S.A., Barcelona) lists French, English, German, Italian, and Portuguese equivalents of the Spanish words. The "Diccionario de la Lengua Española" (sixteenth edition, 1947) published by the Real Academia Española, Madrid, is important. It is of the Webster type and is considered authoritative for the Spanish language as spoken in Spain. Chemical, technical, and other specialized dictionaries in Spanish or other languages are listed in a recent paper by Schaler and Singer (*35*). There are good medical dictionaries in Spain, such as Cardenal, "Diccionario Terminológica de Ciencias Médicas contiene cuantas voces y términos son propios de la Medicina, Cirugía, Odontología, Farmacia, Veterinario y demás Ciencias biológicas" (Salvat y Ca, Editores, Barcelona, 1952, fourth edition, 1325 pp.). This dictionary also lists a great deal of biochemical and organic terminology (*34*). The "Diccionario Médico Aleman-Español y Español-Aleman" by González-Campo de Cos (Marin & Campo, S. L., Editores, Madrid, 1944) lists many chemical terms. The dictionaries of English-Spanish and Spanish-English chemical and medical terminology by M. Goldberg are also mentioned.

Patents and Other Spanish Government Publications

Spain is a member of the Berne Convention, so U. S. citizens have the same rights in registering patents and trademarks in Spain as do Spanish nationals, and they are entitled to the same protection. Patents of invention are usually granted for original inventions (*36*). Pharmaceutical, chemical, or medical formulas are not patentable; only the processes involved. The duration of such patent is 20 years (*36*, *37*). In Spain, any contract by which an employee cedes his rights on a future invention to his employers may be declared void (*38*). Every patent granted in Spain covers the Spanish colonies. Spanish patents may be an important source of information to the chemist searching the literature. Beyond those abstracted in *Chemical Abstracts*, Spanish patents may be found completely in the *Boletín oficial de la Propiedad Industrial*, published by the Ministerio de Agricultura, Industria y Comercio, Registro de la Propiedad Industrial, Madrid (*39*). The *Boletín* first appeared in September, 1886; it is a bimonthly (*40*). As of July, 1954, Spanish patents number around 214,000; they may be obtained either directly from Spain or from the U. S. Patent Office.

Of the government publications of Spain, the monographs of the Instituto Forestal de Investigaciónes y Experiencias, Madrid, should be mentioned. Topics of agronomical and agricultural chemistry are discussed (*41*).

THE CHEMICAL INDUSTRY OF SPAIN

Wherever chemical industry develops and grows, chemical literature flourishes. Before the civil war, the chemical industry of Spain was small and of little importance. Most of the chemicals, especially pharmaceuticals and dyes, had to be imported, but some inorganic industry had been established in the nineteenth century with the help of German, French, British, and Belgian capital. In 1939 the National Syndicate of Chemical Industries was organized. Firms belonging to it are said to have employed over 10,000 persons with a production valued at 500 million pesetas annually (*42*). According to the Dirección General de Sanidad, Madrid, which supervises the registration of pharmaceutical manufacturers and drugs, in 1949 there were around 3000 registered pharmaceutical laboratories in Spain, of which only a small number were in actual operation. Of the more than 36,000 pharmaceuticals and drugs registered for manufacture, only about 20,000 were actually marketed. In 1949, ephedrine, alcohol, vitamin A, liver extracts, ergot, sugar, some alkaloids, sulfa drugs, and essential oils were produced. Five laboratories made sera, vaccines, and biologicals. Penicillin is made in Spain by the Industria Español de Antibioticos, S.A., part of El Consorcio Químico Español (*43*).

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EDITOR'S OUTLOOK

(*Continued from page 393*)

looked. There are two problems in this connection: recruiting teachers and keeping them on the job when they once start; and improving their efficiency. Industry can do at least a little something about both of these.

The recruiting of teachers involves salary considerations. It will be a slow and uncertain process ever to bring teachers' salaries into line with those in industry. But by providing summer employment industry can overcome some of this handicap and at the same time improve teaching efficiency. Efforts in this direction are now under way in many places. This is almost entirely a local matter.

Sponsored research is another form of indirect subsidy for teachers, many of whom are now being maintained largely from this source. Salaries now often come partially from research contracts, and the encouragement for research which they provide is an important consideration in keeping many teachers from drifting away into more lucrative fields.

Educational programs carried on during the summer for selected teachers, like those conducted by the General Electric Company, are providing encouragement and inspiration for many teachers. The burden of many of the Science Fairs, throughout the country, is largely being carried by industry.

All this activity is most encouraging. It is a bright spot on the record of independent enterprise. Now that the courts have upheld the principle that corporate profits may be used for educational aid, the way is clear for industry to play a larger part in the financing of the country's biggest business—education.

For two or three centuries education has become increasingly "socialized," and without doubt this has been one of the factors in the enormous growth of our country. During only the last few decades has independent enterprise adapted itself to the socialized pattern of the modern world, without losing its own identity and vigor. It can and will become an important part of our educational structure.

OUR VERSATILE RUBBERS[1]

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Not many people seem to realize that during 1953 the government of the United States through the Office of Synthetic Rubber and at the request of the rubber manufacturing companies, together with other manufacturers of synthetic rubber, produced much more synthetic rubber than was imported as natural rubber. In other words, 772,000 long tons of these rubbers were manufactured and consumed, while approximately 597,000 were imported. These are striking figures and should be noted with much interest and concern. The Office of Synthetic Rubber manufactured approximately 612,000 tons of GR-S and 77,000 tons of GR-I (Butyl rubber). Du Pont manufactured 66,000 tons of neoprene, and about 30,000 tons of the nitrile rubbers were manufactured by the four large rubber companies. The important silicone rubbers are rolling along and pilot-plant quantities of Hypalon and Chemigum SL are also being manufactured.

Why is it that the quantity of these synthetic rubbers has so far exceeded that of natural rubbers? We should have synthetic rubber manufactured in this country, because we never know when the supply of natural rubber can again be cut off from the Far East, even as it was at the time of our entrance into World War II. Furthermore, these synthetic rubbers have properties which permit them to be used where natural rubber is of less use or of no use at all. The silicone rubbers are low in volume but they can withstand temperatures from −130°F. to +500°F., and at these temperatures natural rubber is like a board or softens to a soup. Very important to all of you, since you all ride automobiles, the GR-S treads of your passenger-car tires are better than those ever made with natural rubber. The rubber used in automobile tires is about 70 per cent of the total amount consumed, and therefore the reason for the large amount of GR-S being produced is readily seen. Furthermore, the Butyl-rubber inner tubes for tires hold air at least ten times better than natural-rubber tubes, and therefore you do not even worry about blowing up your tires at all. Butyl rubber sells for 23 cents a pound. Natural rubber swells in many oils, solvents, and greases and cannot compete with nitrile rubbers and Thiokol, which swell very little or not at all in the same materials. Similarly, it must be remembered that natural rubber slowly deteriorates when stretched in the atmosphere because the ozone in the atmosphere attacks rubber and causes surface cracks. We now have several synthetic rubbers that are not attacked by ozone at all, and a few to a very minor extent. There are also synthetic rubbers which do not burn or carry a flame.

GR-S is by far the principal synthetic rubber in production and it is made in two types. Both types are prepared from 78 parts of butadiene and 22 parts of styrene. Butadiene is a gas and styrene boils at 145°C. They are emulsified in water in a large closed tank, a peroxide and a modifying agent are added, and the mixture is stirred at a temperature of 122°F. for approximately 15 hours. At the end of this time 65–70 per cent of the polymerization has been completed and a stopping agent is added to destroy the peroxide, the excess of butadiene and styrene is removed and recovered, an antioxidant is added, and the synthetic rubber is coagulated with a solution of salt and sulfuric acid, washed, dried, and baled. This type is still manufactured, but another type is in production because it has properties better than the earlier type. This second form is also prepared in an emulsion but the types of peroxide and activating agent are different, allowing the reaction to go on at a temperature of 41°F. instead of 122°F. That is why it has been called "cold rubber." This rubber has better processing properties, and with the new type of furnace black it gives us the best tread available. About 75 per cent of this total GR-S is now being manufactured as "cold rubber."

GR-S is a general, all-purpose rubber and can replace natural rubber in nearly all of its uses. Its chief drawback is its higher hysteresis when stretched rapidly. Rubber gives off heat (the Joule effect) and since rubber also is a poor conductor, heat will accumulate in a tire. The passenger-car tires are now designed to take care of this heat even though GR-S gives more heat and actually can withstand more heat. However, for truck tires only about 10 per cent GR-S can be used satisfactorily.

A recent development of GR-S is to allow the reaction to go to a higher per cent of polymerization, producing a tougher product which by itself cannot well be handled in rubber machinery. The addition of approximately 25 parts of petroleum oil to 100 parts of the tough GR-S allows it to be milled, and thus the higher molecular weight material can be used in tires and other products. The oil is emulsified and added to the synthetic rubber latex which is then coagulated, washed, and dried, and a master batch is thus prepared. Even higher proportions of the oil may be

[1] Presented at the Midwest Meeting of the American Chemical Society, Omaha, Nebraska, November 4, 1954.

used, sometimes with advantage. The use of the oil is desirable because it costs only from two to four cents a pound, whereas the GR-S is 24 cents a pound.

The carbon black can also be emulsified and added to synthetic rubber latex and thus a master batch is prepared. This is of interest because carbon black is very finely divided and floats all around in the atmosphere of a rubber plant when it is being milled; as a master batch the rubber and black can be handled very well.

Changes are being made on the preparation time of the two types of GR-S; the Research and Development Division has had much to do in developing these changes and in the production of a proper GR-S. It is hoped that this division will be carried on even though the plants are disposed of to industry.

One of the newer developments is to prepare the GR-S in a tube at the very rapid rate of about five minutes instead of 15 hours. The process is not very difficult and not even very different from that ordinarily used.

Just the manufacture of GR-S shows that the synthetic-rubber industry is big business, and it is big chemistry business. The butadiene is manufactured by the petroleum companies although some of it is still being prepared from alcohol, and the chemical companies are manufacturing the styrene and other products that are used. All these plants are being offered to the industry under properly guarded methods which will keep the industry and the public in balance. The present law states that the plants can be disposed of to industry by April, 1955. Many conferences will have to be held in order to carry through these negotiations. These plants are not war surplus and it is very desirable—in fact necessary—to have synthetic rubber in manufacture or the plants in standby condition ready for manufacture.

The other synthetic rubber manufactured under the Office of Synthetic Rubber is GR-I, or Butyl synthetic rubber. This synthetic rubber is being manufactured under contract by the Standard Oil Company. It is prepared from 97 parts of the cheap gas isobutylene, and three parts of isoprene in the presence of a Friedel-Crafts catalyst, aluminum chloride, at −140°F. It is a very different process but is exceedingly rapid. This is the rubber being used for inner tubes because of its high impermeability to air as compared with natural-rubber tubes. It is also somewhat resistant to ozone and many other chemical agents.

Neoprene is the synthetic rubber nearest in properties and uses to natural rubber. It is a polymerized chloroprene which has a chlorine atom in place of the methyl group of isoprene, and is prepared by starting with acetylene. Like natural rubber it has a high pure-gum tensile strength, whereas that of GR-S is low. A pure gum has only the normal proportions of the ingredients to vulcanize it. Neoprene, as a matter of fact, does not require sulfur for vulcanization. Nor is it affected by ozone as rapidly as natural rubber which is more strongly affected by ozone, and it does not resist the swelling action of many oils and greases.

Twenty years ago the Germans learned that butadiene could also be polymerized with acrylonitrile and the nitrile rubber thus prepared showed good aging and especially low swelling in oils, solvents, and greases. Only about 30,000 tons of the nitrile rubbers are manufactured annually, but they are very useful because of the low oil-swelling properties. All four large rubber companies manufacture them under the names of Butaprene N, Chemigum N, Hycar OR, and Paracril.

Silicone rubbers are the ones that have such a tremendous range in temperature properties. They are chemically different from the other synthetic rubbers in that they contain a chain of atoms consisting alternately of silicon and oxygen, rather than only carbon. The polymers do contain carbon groups but not in the chain. Silicon is much like carbon, but the polymer gives the remarkable temperature properties mentioned. It is far more expensive than the other rubbers but it is colorless, is not much affected by some of the solvents, and is vulcanized with benzoyl peroxide and not by sulfur. The molecular weights of the silicone rubbers are also very high, running up almost to three million in some cases.

Thiokol, manufactured in this country in 1930, was the first commercial synthetic rubber. A year later it was followed by neoprene. Thiokol has a very high resistance to the swelling action of solvents. It also has a high impermeability to vapors and gas and high resistance to oxygen, light, and ozone. Unfortunately, it has a bad odor in some of its types which prevents its use in many cases.

Polyacrylates are prepared from ethyl acrylate and have the properties of high heat resistance, good weather resistance, and solvent and ozone resistance.

Two additional types are now available in small quantities and they both have very interesting properties, particularly in that they are not affected by ozone which means that they are excellent in withstanding the effect of weather and are also good in handling chemical oxidizing agents and other corrosive materials.

Hypalon is a chlorosulfonated polyethylene. Polyethylene is found in every kitchen in the flexible plastic pitchers, cups, and plates being manufactured from it. Ethylene is our simplest unsaturated hydrocarbon and it is polymerized under heat and pressure and then chlorinated in the presence of sulfur dioxide until it contains about 27 per cent chlorine and 1.5 per cent sulfur. It is only being manufactured in pilot-plant quantities today, but it looks as if it has an excellent future. Tubes can be made of it which handle concentrated nitric or sulfuric acid.

One other product should be satisfactory, and that is the Vulcollan type which has been handled on a small scale in Germany and now is being manufactured in this country, also on a small scale, by the Goodyear Tire and Rubber Company, and is called Chemigum SL. It is prepared from a polyester of adipic acid and

ethylene glycol and then treated with a naphthalene diisocyanate which costs from four to five dollars a pound and makes up about half of the final product. This type of rubber has a high pure-gum tensile, has twice the abrasion resistance of natural rubber, and requires neither carbon black nor fabric because it has a remarkable resistance to tear. It is not easy to manufacture, especially to handle, because there are stages in which it sometimes must be handled within a few hours or a few months in order to mold it and get it into its proper final condition. There is a possibility of making tires from this material which ought to last the life of your car; certainly at least 100,000 miles. There are many problems still to be solved but good research will solve them. Vulcollan is white and a tire could be prepared of the color of the car or to complement the color of the car.

Thus is it seen that the synthetic rubbers give us remarkable properties which cannot be obtained from natural rubber. We must not forget, however, that natural rubber is very usable and should be brought into our country. The synthetic rubber business is very interesting chemically and produces wonderful products. Let us watch its remarkable development.

FUNDAMENTALS OF THE ANALYTICAL BALANCE

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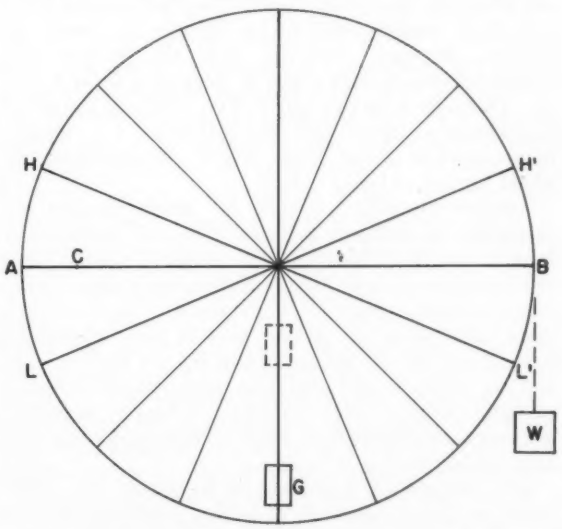
THE analytical balance is one of the important tools in the laboratory. Its usefulness increases when the chemist understands its operation well enough to utilize the full capabilities and to realize the limitations of the balance.

Some chemistry students do not become proficient in the use of the balance because, understandably, they are concerned with so many other and complex instruments and problems. The balance is taken for granted. It may be that, because balances have been used for so many centuries, intuitive knowledge about them is assumed. At the other extreme are those who know there is something precise and presumably delicate about a balance, and so they avoid using one if possible. This is unfortunate because mass, along with length and time, is a fundamental measurement. An example is the use of a balance to prepare standards for the calibration of more specialized instruments. Another important thing about a balance is its high ratio of capacity to sensitivity. Few measurements will yield as many significant figures as a weighing on an analytical balance. Results to six significant and exact figures are ordinary.

Those who have learned about balances by an intuitive process tend to think of them as teeter-totters. Actually a balance is a compound pendulum with complications. The essentials of the operation can be understood easily, however, by visualizing an upright wheel free to turn on a fixed axle.

A weight G clamped around one spoke will cause the wheel to rotate until that spoke finally comes to rest directly under the axle. Then, if a small weight W is



suspended from a string attached to point B, the wheel will turn clockwise and come to rest with B lower than its original position. Two things have happened. A new center of gravity has been established and has

sought its place under the axle or point of suspension; and the weight W, descending, has done the work of lifting G to its new position.

Little weight W will cause the wheel to turn more if G is clamped on its spoke near the hub, and less if G is clamped near the rim. Attaching W causes a lateral shift in the center of gravity. This shift represents fewer degrees of rotation when the original center of gravity is near the rim than it would with the center of gravity near the hub. For those not interested in the mental exercise of calculating the forces involved, it is sufficient to get the idea that W has more leverage on G when G is near the axle which acts as the fulcrum.

It is easy to see, too, that small weight W suspended from B will turn the wheel faster if the wheel is light than it would if the wheel were a heavy one. With the wheels of equal weight, the one with a heavy hub and light rim would turn faster than one with a heavy rim and light hub. This is simply a matter of inertia.

The wheel will not turn one way or the other if heavy and equal weights are suspended from both points A and B. Adding the small weight W will make the wheel turn exactly as before. The heavy weights have no effect other than to slow the rotation and to increase the friction against the axle. Ignoring the friction, the rest point will be exactly the same whether or not equal weights are suspended from A and B.

If the heavy weight supposedly at A is really at C, the wheel will turn clockwise *before* little weight W is added. The heavy weight at B has a longer lever arm than the equally heavy weight at C. The addition of weight W at B will make the wheel turn an additional amount.

The heavy weights when suspended from A and B do not affect the rest point because they have equal lever arms and because they do not change the center of gravity. Suppose, however, that the weights are suspended from points L and L' instead of from A and B. This *does* lower the center of gravity, and the effect is the same as lowering G nearer the rim, *i. e.*, weight W attached to point B (or to L') will not cause the wheel to turn as far as before.

Another possibility is that the heavy weights are suspended by strings from points H and H' rather than from A and B. This raises the center of gravity, and has the same effect as raising G nearer the hub. With this condition, weight W will cause the wheel to turn more than when the heavy weights were suspended from A and B. If points H and H' are high enough and the weights suspended from these points are heavy enough in relation to G, the wheel will turn completely over because the center of gravity has been raised to the axle and beyond.

The purpose of a balance is to detect the small weight suspended from B, or to put it another way, to detect an equally small difference between weights suspended from A and B. To do this, the wheel must turn a detectable amount when the total weight on one side is smaller or larger than the total weight on the other side. Moreover, it is desirable that the wheel always turn the same amount whenever the same difference exists between the total weight on the two sides. This makes it possible to interpret the amount of rotation in terms of weight rather than to counterbalance the two sides in order to make a weighing. Also, if the same difference in weight turns the wheel the same amount under all conditions, the smallest difference that can be detected will be the same under all conditions.

Superimposing the concept of a balance beam on the wheel, we see that there are several conditions to be met if the balance is to detect a small weight, or small differences in weight, consistently under various loads.

(1) There must be very little friction in the axle. This condition is met in an analytical balance by supporting the whole moving system on a sharp straight knife edge resting on a flat plane. The only friction is that caused by the knife edge's rocking through a small arc on the plane.

(2) There must be very little friction in the strings which suspend the various weights. If the strings are stiff, they will have the effect of fastening the weights rigidly to the wheel with the resulting complications of having the size and shape of the weight affect the center of gravity. Here again the knife edge and plane are used in analytical balances. The hangers which hold the weights and samples are suspended from planes which rest on the knife edges in the ends of the beam.

(3) The weights must be suspended from points A and B, not C and B. This is accomplished by having the end knife edges of the beam in a balance equidistant from the center knife edge.

(4) Again, the weights must be suspended from points A and B, not L and L' nor H and H'. This means that, in a balance, the bottom of the center knife edge must be in the same horizontal plane as the tops of the upturned end knife edges.

(5) The weight G must be near the hub and not down near the rim. In an analytical balance this requirement is met by using a beam designed so that the center of gravity of the beam and all parts attached rigidly to it are just below the center knife edge.

(6) The wheel must be light in weight. The moving systems of analytical balances are made largely of aluminum and are stripped of all unnecessary attachments.

(7) Most of the weight of the wheel should be near the hub rather than the rim for faster rotation. In a balance this is accomplished again by the design of the beam, and by the use of a shorter beam. Theoretically a longer beam would give more sensitivity, but would slow the swing, and might bend under load if the beam were of light construction.

(8) Two additional requirements of an analytical balance are in the third dimension, and so are not shown by the wheel. The first is that all three knife edges, as viewed from above, must be parallel. The reason can be visualized by assuming that the left knife edge is closer to the fulcrum at its back end than

at its front end. Then if a heavy weight were to be placed on the back of the left pan, any friction in the suspension could throw more of the load on the back end of the knife edge. The effect would be to shorten that side of the beam, like suspending the weight from C instead of A.

(9) Similarly, the knife edges must be in the same horizontal plane all along their lengths. If one end edge is higher at the back than at the front and more weight falls on the back, the effect is that of suspending the weight from H rather than A.

In summary, a balance will weigh accurately without requiring special techniques only if the beam is designed properly and if the three knife edges in the beam are parallel, equidistant, and coplanar. The relative positions of the knife edges cannot be exact. As a practical matter, some tolerance must be allowed. The surprising thing is how small the various tolerances are in modern American balances. In the all-important spacing of the end knife edges, for example, accuracies to a part of one hundred-thousandth of an inch are common.

The important thing to the user is the accuracy in milligrams, not in inches, when the balance is used in various ways. The characteristics of any balance can be determined quickly by means of a few simple tests, and proper allowance for any shortcomings can be made thereafter.

To make the tests, the first step is to find the zero point of the balance when the pans are empty. This can be done by letting the beam swing until it comes to rest, by averaging the swings to calculate the rest point, or simply by using the turning point of the first swing as the reading. The last method can be used only if the pan rests are adjusted so that they do not give the beam a "kick" one way or the other on release. With any method of reading the pointer it will be most convenient to set the balance so that the zero or rest point is the zero line in the center of the pointer scale. This is done with the zero-adjusting rider or other means provided.

To test the sensitivity of the empty balance, a suitable small weight is placed on one of the pans and a reading is taken. A two-milligram weight is suitable for the usual "student" balance with a $^1/_{10}$-milligram rated sensitivity. This little weight will swing the pointer out possibly five divisions and change the rest point approximately $2^1/_2$ divisions. This test shows the lack of friction in the bearings and the height of the center of gravity. (G is near the hub, not the rim.)

To determine whether the two arms of the beam are equal in length, the small weight is removed and two heavy and equal weights are put on the two pans. They should each be 100, or preferably 200 grams for a balance with a 200-gram capacity. If the added weight causes the pointer to move to the left, the right arm is longer. (The weight on the left side is suspended from C rather than A.) It is unlikely that the two heavy weights will be exactly equal so they are exchanged between the pans and another reading taken. The midpoint between the two readings is the result due to inequality in length of the two arms of the beam; the spread between the two readings is due to the inequality of the weights.

For the next test the two heavy weights are left on the pans and the zero point is readjusted to the center line on the pointer scale. Then the same small (two-milligram) weight is placed on one of the pans and a reading taken to show the sensitivity of the loaded balance. If the same small weight swings the pointer farther when the pans are loaded than it does when the pans are empty, the end knife edges are high (at H and H'). Loading the pans certainly has not reduced the friction, so it must have raised the center of gravity resulting in more rotation from the same force. If the swing is less with a load on the pans, the end knife edges are probably low (at L and L'). Loading the pans has lowered the center of gravity. The lesser swing with added load also may be due in part to dull knife edges, the added friction they cause, and the damping action caused by their rocking on a radius which makes the higher arm longer.

To differentiate between low end edges and dull knife edges, the decrease in successive swings is noted. Dull edges decrease the oscillations more rapidly. With sharp edges on a free-swinging balance each oscillation is nearly as large as the previous one whether or not there is a load on the pans.

These four tests, sensitivity empty, change in rest point when load is added, sensitivity loaded, and deceleration of the swing, show the characteristics of a balance and have definite utility to the user. They show the limits of accuracy of the balance when used in a normal manner, and they point to ways of increasing the accuracy of the results by the use of special procedures when required. For example, the sensitivity of the balance at various loads can be charted to show the correct interpretation of the pointer reading with any load on the pans. More important perhaps is that this chart will show how many digits in a weighing are significant. When inequality in the relative length of the two arms of the beam prevents the weighing accuracy required, two solutions are possible. One is to chart the corrections necessary at various loads to compensate for error caused by the comparative lengths. The other is to use the substitution or transposition method of weighing. Techniques or methods cannot increase the accuracy of a balance limited by dull knife edges. Such a balance should be demoted to jobs requiring less accuracy. On the other hand, a well-understood balance, with sharp edges, can be relied on to yield accurate results for a long time.

INORGANIC PREPARATIONS: AN INTRODUCTION TO INORGANIC CHEMISTRY

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In recent articles by Sisler[1] and Sanderson,[2] the need for more professional inorganic chemists has been emphasized. Sisler has pointed out some of the industrial fields, in particular, that are feeling the shortage of trained personnel, and has suggested several ways of stimulating interest in inorganic chemistry in our colleges and universities.

The University of Toledo, like many universities of its size, has been rather slow in developing a program in inorganic chemistry. This situation is essentially the result of two factors: the small number of chemistry majors, and the elective nature of the inorganic chemistry courses. A one-semester course in theoretical inorganic chemistry is offered every two years. Likewise, a course in advanced quantitative analysis, in which inorganic principles as well as analytical methods are stressed, is given every other year. The scheduling of these courses only means that they will be offered if a sufficient number of students (at least ten) is enrolled. A third course, preparative inorganic chemistry, is given every semester on a seminar basis.

Until 1954 the preparation course was strictly a "mechanical" course, wherein the student was handed a list of preparations and a list of available library references pertaining to the preparations, and told to complete the work by the end of the semester. No formal lectures were given and the student was left to his own devices. This may or may not be the proper way in which to conduct such a course; there are arguments for both sides. However, such a course soon gets a "reputation" and most students shy away from the course, especially when it is elective in nature.

In an effort to stimulate more interest in inorganic chemistry, the status of the preparation course was changed in the fall of 1954. Since very few students are eager to take an elective laboratory course, it was obvious that the course itself had to be made interesting as well as challenging to the student, and be presented in such a way as to give the student a broad view of inorganic chemistry. Gayer and Elkind[3] have outlined a lecture and laboratory course in preparative inorganic chemistry for college seniors, using freshman, chemistry, qualitative analysis, quantitative analysis, and intermediate inorganic chemistry as prerequisites. The revised preparation course offered by the author and described in this article has only the first three of these as required background courses. The program of the course now calls for one 50-minute lecture period and eight hours of laboratory work per week. A special laboratory has been equipped for the course, and each student is issued a key to the laboratory and given a free choice in selecting his laboratory time. The topics covered in the weekly lectures are summarized as follows.

Week 1. Each student is assigned ten preparations and given a list of references pertaining to the preparation of inorganic compounds. Instructions are given for the writing of the final semester report. Each student is required to use a German reference (Vanino) in at least one of his preparations. The report is to include, for each assigned preparation: (*a*) a brief summary of the methods listed in the references for the preparation; (*b*) a detailed outline of the procedure used by the student; and (*c*) the yield and properties of the preparation.

Directions are also given for the proper maintenance of the laboratory notebook and for the use and care of special laboratory equipment.

Week 2. The common metals—general methods of preparation and properties with respect to position in the periodic table.

Week 3. Nonmetals—general methods of preparation and properties with respect to position in the periodic table.

Week 4. Metallic and nonmetallic oxides—general methods of preparation and properties.

Weeks 5 and 6. Acids and bases—general methods of preparation, ionization constants, predicting ionization constants from type formula, relative strengths with respect to position of metal and/or nonmetal in the periodic table.

Weeks 7 and 8. Acids and bases—Arrhenius, Brönsted, Franklin, and Lewis theories.

Week 9. Salts—general methods of preparation and purification.

Week 10. Hydrates.

Week 11. Elementary techniques in glass blowing.

Week 12. Atomic structure and the nature of the coordinate bond.

Week 13. Directional coordinate bonding and molecular configuration.

Week 14. Isomerism in inorganic coordinate compounds, nomenclature of such compounds, and general methods of preparation.

Week 15. Preparation and purification of some of the common gases.

The preparations assigned to each student are se-

[1] Sisler, H. H., J. Chem. Educ., **30**, 551–3 (1953).
[2] Sanderson, R. T., *ibid.*, **32**, 41 (1955).
[3] Gayer, K. H., and M. J. Elkind, *ibid.*, **30**, 90–3 (1953).

lected to represent as many of the principles discussed in the lecture portion of the course as possible. During the lecture on metals (Week 2), for instance, various students are called upon to describe the method selected for the preparation of their particular metal. This same procedure is used for many of the preparations to correlate the lecture and laboratory work. The student's participation in the classroom discussions tends to keep his laboratory work going at a fairly even pace and discourages his letting the work go until the end of the semester.

The following is a typical set of preparations assigned to the student.

(1) Preparation of a metal, such as Cr, Mn, Ni, etc., from the metallic oxide, to illustrate the use of hydrogen, carbon, and aluminum as reducing agents.

(2) Preparation of an oxide, such as PbO_2, I_2O_5, Cu_2O, etc.

(3) Preparation of an acid, such as HIO_3, H_3BO_3, H_3PO_4, HBr (constant boiling).

(4) Preparation of a simple salt, such as NaCl (from rock salt), KCl, etc., to illustrate the problems of purification by fractional crystallization.

(5) Preparation of a double salt, such as the many alums. Large crystals are required and these are examined by the class at the end of the semester.

(6) Preparation of a salt of a metal in its lower valence state, such as Cu_2Cl_2, $FeCl_2$, etc.

(7) Preparation of a complex salt, such as $Co(NH_3)_6Cl_3$, to illustrate cation complexing.

(8) Preparation of a complex salt, such as $K_3Co(C_2O_4)_3$, to illustrate anion complexing.

(9) Preparation of a thio-compound, such as Na_2CS_3, K_3SbS_4, etc.

(10) Preparation of a sealed-tube product, such as NO_2, Cl_2, $NOHSO_4$, etc.

The nature of the topics covered and the preparations assigned makes the course an introduction to, rather than an extension of inorganic chemistry. The students' lack of background in inorganic chemistry prevented the author from delving too deeply into any one subject and presenting excessive amounts of advanced material. However, the author found that he was able to tie together a lot of loose ends and bits of information acquired by the students in their previous chemistry courses. Sufficient interest was created in the class to cause several of the students to inquire into the possibility of the department's offering a second, more advanced course in the subject. This sentiment more than justifies the work of revising the course and encourages further changes in our inorganic program.

No one textbook can be singled out as being adequate for the course, although "Inorganic Preparations," by Walton, is recommended, for it covers many of the principles discussed during the semester's work. The following books are those listed for the students as references for the lecture and laboratory portions of the course.

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"Laboratories are necessary, and, though an artist without a studio or an evangelist without a church might conceivably find under the blue dome of heaven a substitute, a scientific man without a laboratory is a misnomer."

Frederick Soddy, 1877

PHASE EQUILIBRIA AND THE CHEMICAL POTENTIAL

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EVERY student in the course in elementary physical chemistry has probably memorized the equation $d\mu = -\bar{S}\,dT + \bar{V}dp$ and has seen the related equations $\left(\frac{\partial \mu}{\partial T}\right)_p = -\bar{S}$, and $\left(\frac{\partial \mu}{\partial p}\right)_T = \bar{V}$. However, the significance of these relationships may easily escape him. It is the purpose of this article to present several graphic examples of these relations which I have found helpful in presenting the subject of phase equilibria to an elementary class. These are discussed below under several different headings. The symbols used are defined in the table.

Symbol	*Significance*
μ	the chemical potential; in a one-component system, the molar free energy
μ^0	chemical potential of pure liquid solvent
$\bar{S}$	the molar entropy
$\bar{S}^0$	molar entropy of pure liquid solvent
$\bar{V}$	the molar volume
$\bar{V}'$	partial molal volume of solvent in solution
T	the temperature (Kelvin scale)
p	the pressure
s, liq, g (superscripts)	solid, liquid, gas
F	Gibbs free energy
R	the gas constant

THE IMPORTANCE OF THE DIFFERENTIAL EQUATIONS

There are two methods of investigating a thermodynamic function experimentally. The first one is to measure the property directly. This method can be applied to such properties as volume or pressure. By an appropriate series of measurements one readily obtains the volume as a function of temperature and pressure. The majority of the thermodynamic functions are not capable of direct measurement; these functions must be investigated by studying their derivatives. This second method of investigation does not yield such a complete knowledge of the function as does the first method. There always remains the constant of integration. Setting this integration constant equal to zero in a specified standard state is a device of convenience and does not increase our knowledge of the function in the slightest. Functions of this second type are the internal energy, the enthalpy, and the free-energy functions. (Temperature and the entropy have special properties and so are excluded from the above discussion.)

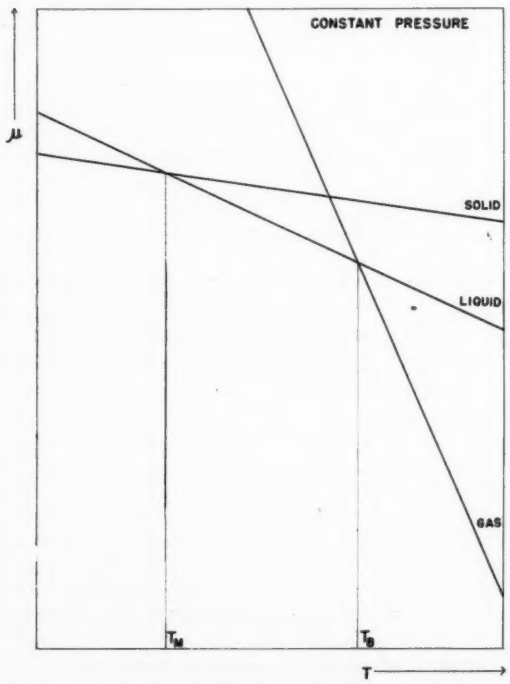

Figure 1. Isobaric Plot of Chemical Potential Versus Temperature for a Pure Substance

Since we cannot measure the chemical potential of a substance directly it is necessary to examine the derivatives of this function, since these derivatives show how the value of the function changes with the independent variable. The two equations which are of interest here are:

$$\left(\frac{\partial \mu}{\partial T}\right)_p = -\bar{S} \qquad (1)$$

$$\left(\frac{\partial \mu}{\partial p}\right)_T = \bar{V} \qquad (2)$$

The molar volume of a pure substance has a rather important algebraic property: the molar volume is always positive. Thus, equation (2) says that an isothermal increase in pressure always produces an increase in the chemical potential of a pure substance. Furthermore, the increase in chemical potential per unit increase in pressure is proportional to the molar volume; for gases the increase will be large, for condensed phases it will be comparatively small. (It is unfortunate that

many textbooks convey the impression that the principal use of this equation is as an exercise in substituting RT/p for $\bar{V}$ and integrating between limits.)

Examining equation (1) in the same way, one observes that the entropy of a pure substance is always positive. Consequently, an isobaric increase in temperature always produces a decrease in the chemical potential of such a substance. This decrease in chemical potential per degree is proportional to the molar entropy; thus, the decrease per degree is larger for a gas than for a liquid, and larger for a liquid than for a solid.

Using the equations (1) and (2) in the form given above and the principle that the stable phase is the phase having a minimum value of the chemical potential, one can learn some interesting things about phase equilibria in simple systems.

ISOBARIC VARIATION OF CHEMICAL POTENTIAL WITH TEMPERATURE

Consider the behavior of a one-component system under a constant pressure. The variation of the chemical potential with temperature is expressed by equation (1). If μ is plotted against temperature, one obtains a curve (represented schematically in the figures as a straight line) with a negative slope since the entropy is always positive. Bearing in mind that for a given substance at any specified temperature $S^s < S^{liq} < S^g$, three curves are obtained. These are shown in Figure 1. The first curve has a comparatively small negative slope and is the proper curve for the solid. The curve for the liquid has a somewhat larger negative slope and the curve for the gas has the largest negative slope. From the appearance of this diagram certain properties become geometrically obvious.

The temperature axis is divided into the three intervals. Below T_m the solid phase has the lowest chemical potential. Between T_m and T_b there is an interval in which the liquid has the lowest chemical potential. Above T_b the gas phase has the lowest chemical potential. In this way one can illustrate the familiar sequence of phases traversed by a system as the temperature is increased at constant pressure. It should be noticed that the relationship between the various lines does not depend at all upon the numerical values of the chemical potential. However, the positions of the lines do depend on the relative values of the chemical potential. A solid can be warmed and it remains stable until a definite temperature is reached at which it melts. A liquid can be heated but finally boils at a definite temperature. Above this temperature the gas simply heats up.

Considering the regions near T_m in detail, it is noticed that at temperatures below T_m the liquid, which is unstable, can decrease its chemical potential by solidifying isothermally. At temperatures above T_m the solid, which is unstable in this region, can decrease in chemical potential by liquefying isothermally. However, at the intersection point T_m, where the chemical potentials of the two phases are equal, neither the solid nor the liquid can lower its chemical potential by changing its state of aggregation. At T_m neither phase is preferred; both phases coexist in equilibrium. The geometrical condition for the intersection point, $\mu^s(T,p) = \mu^{liq}(T,p)$, is the thermodynamic condition for the equilibrium point. The equation $\Delta F = 0$, which is often used in texts as the equilibrium condition, does not have such an immediate meaning on the diagram.

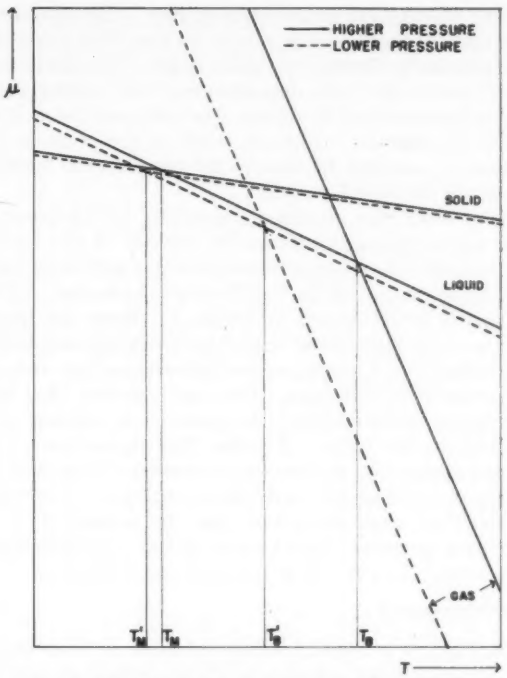

Figure 2. Isobaric Plot of Chemical Potential Versus Temperature for a Pure Substance at Two Different Pressures

Logically, one can now ask how the diagram looks if it is drawn at a different pressure. To construct the diagram at a different pressure one needs only the information provided by equation (2). Suppose that the new pressure is lower than the original pressure; then dp is negative and at every temperature the chemical potential will have a lower value. The decrease in the chemical potential is in direct proportion to the volume of the phase in question. Thus, for a given decrease in pressure the decrease in chemical potential of the gas will be roughly 1000 times larger than the decreases for the liquid and solid. (This assumes that the pressures in question are of the order of one atmosphere.) In Figure 2, the full lines refer to the higher pressure; the dotted lines refer to the lower pressure. (It is necessary to exaggerate the separation between the full and dotted lines for the solid and liquid since the actual separation is very small. The figure is drawn for the case: $\bar{V}^s < \bar{V}^{liq}$.)

Figure 2 has a number of interesting features. Both

of the intersection points have shifted. The change in the melting point is very small; on the other hand, the shift in the boiling point is quite large. This illustrates very neatly the large dependence of the boiling point on the pressure and the slight dependence of the melting point on pressure. The net result of the pressure decrease is a marked decrease in the temperature interval in which the liquid is stable.

It is clear that continued reduction of the pressure will again reduce this range of stability of the liquid. Ultimately, the intersection of the gas and solid lines will lie to the left of the liquid-solid intersection. This situation is illustrated in Figure 3. Here the liquid phase is omitted in the sequence of aggregation states traversed by the system as the temperature is increased. The substance sublimes. One can conclude that any substance will sublime if the pressure is reduced to a sufficiently low value. Whether this will be observable in the laboratory at very low pressures will depend on the properties of the individual substance. One condition that must be met is that the normal (*i. e.* at one atm. pressure) liquid range of the substance must not extend over too large a temperature interval.

REFINEMENTS

In Figures 1, 2, and 3 the curves have all been drawn as straight lines. Actually, these curves should be convex upward since the entropy increases monotonically with temperature. Also, if the curves were continued to low temperatures all of them would have to have zero slope at the origin of temperature. These refinements are not pertinent to the discussion presented here.

THE CLAPEYRON EQUATION

The condition of equilibrium between two phases, α and β, is written as $\mu^{\alpha}(T,p) = \mu^{\beta}(T,p)$. If the form of these functions were known the equation could be solved for one variable as a function of the other. That is:

$$T = f(p) \tag{3}$$

or

$$p = g(T) \tag{4}$$

Equation (3) simply expresses the fact, observed in Figure 2, that the equilibrium temperature depends upon the pressure.

In the absence of a knowledge of the exact form of the functions one can nonetheless obtain an expression for the derivative of the functions (3) or (4). The equilibrium condition determines one variable as an implicit function of the other. By the usual rule for differentiating an implicit function one gets the Clapeyron equation:

$$\frac{dT}{dp} = \frac{\Delta V}{\Delta S}$$

or

$$\frac{dp}{dT} = \frac{\Delta S}{\Delta V}$$

From the discussion and the manner of writing equations (3) and (4) it is clear why the left-hand side of the Clapeyron equation involves a total derivative and not a partial derivative.

At the triple point, the solid-liquid intersection point coincides with the liquid-gas intersection point. Here two relations hold:

$$\mu^{s}(T,p) = \mu^{liq}(T,p)$$
$$\mu^{g}(T,p) = \mu^{liq}(T,p)$$

These two equations can be solved for the two unknowns with the result that:

$$T = \text{a definite value}$$
$$p = \text{a definite value}$$

Thus, the triple point is unique.

THE ISOTHERMAL VARIATION OF CHEMICAL POTENTIAL WITH PRESSURE

The chemical potential versus pressure diagram can be constructed in a manner analogous to that used in the construction of the chemical potential versus temperature diagram. However, it is not so well suited to class presentation since the student is not as familiar with the phenomena occurring during isothermal compression of a substance as he is with those associated with isobaric heating.

COLLIGATIVE PROPERTIES

The chemical potential-temperature diagram is well suited to illustrate the colligative properties of a solution. As an example, consider an ideal liquid solution containing an involatile solute and which on cooling yields crystals of pure solvent. This example is particularly simple because the solute appears only in the liquid phase. The chemical potential of the pure solvent is plotted as a function of temperature in Figure 4 (solid lines). This diagram needs only one modification to make it appropriate to a solution of the type described above. For the solution only the solvent is present in the solid and gas phases; therefore, the solid and gas curves are unaltered. However, the chemical potential of the solvent in the liquid phase is given by the expression:

$$\mu(T,p) = \mu^{0}(T,p) + RT \ln x$$

in which $\mu^{0}(T,p)$ is the chemical potential of the pure liquid solvent, and x is the mole fraction of the solvent in the solution. Since the second term on the right-hand side of the equation is negative, the line for the chemical potential of the solvent in the solution must always lie below the line for the pure solvent. The dotted line in Figure 4 represents the chemical potential of the solvent in the solution. The slope of this dotted line is slightly more negative than that of the line for the pure solvent since $\left(\frac{\partial \mu}{\partial T}\right)_{p} = -\bar{S}^{0} + R \ln x$. Thus, the dotted line is rotated slightly in a clockwise direction when compared to the line for the pure solvent.

In Figure 4 the relations between the lines make it geometrically obvious that: (1) the freezing point of

the solution is below that of the solvent; (2) the boiling point of the solution is higher than that of the solvent; (3) at any specified concentration, the freezing-point depression is larger than the boiling-point elevation. Only the third point needs discussion, since the increased negative slope might be sufficient to rotate the line so that the freezing-point depression would be comparable to or even less than the boiling-point elevation. If $x = {}^1/_2$ (a very concentrated solution), the increase in the negative slope is of the order of $-R = -2$ cal./deg.-mole. If, for example, water is the solvent, the molar entropy of water at 25°C. is 45.106 cal./deg.-mole. In this case the slope of the line is increased by only about four per cent. This is not enough to destroy the validity of the geometric observation, (3). In more dilute solutions the change in slope is even less.

OSMOTIC PRESSURE

The osmotic pressure does not appear on the diagram in as striking a fashion as do the other colligative properties. However, one can make the following interpretation. The osmotic pressure is defined as the increment in pressure on the solution which is sufficient to restore the chemical potential of the solvent in the solution to the value proper to the pure solvent at that same temperature. Thus, at a given temperature the point on the dotted line in Figure 4 must be pushed up to the corresponding point on the full line by applying pressure on the solution. To restore the dotted point to the full line requires an increase of chemical potential of solvent equal to $-RT \ln x$; the increase in chemical potential caused by a pressure increment is $\bar{V}'\Delta p$. When these two increases are equal, Δp is the osmotic pressure, π. The equation for the osmotic pressure is then: $\pi\bar{V}' = -RT \ln x$. (The dependence of $\bar{V}'$ on p and x is neglected in this equation.) Since the chemical potential of the solvent does not change very much with change in pressure, the osmotic pressure is rather large even in dilute solutions. For example, in a solution which has $x = 0.99$, $-RT \ln x = 240$ cc.-atm. at ordinary temperatures; while $\bar{V}' = 20$ cc. for water (approximately). Consequently, $\pi = 240/20 = 12$ atm.

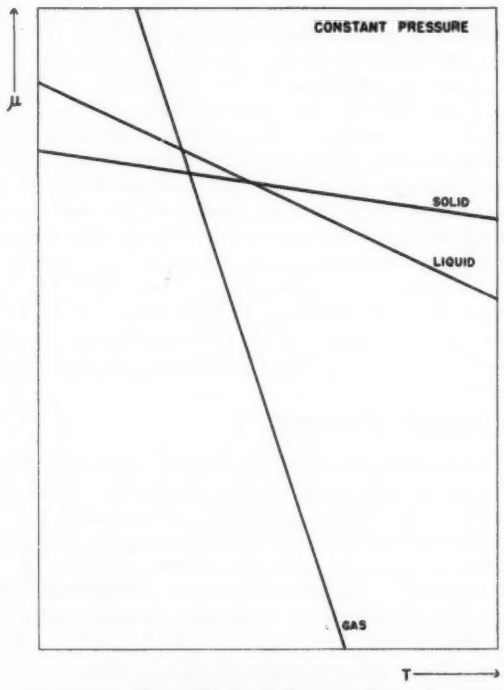

Figure 3. Isobaric Plot of Chemical Potential Versus Temperature for a Substance Which Sublimes

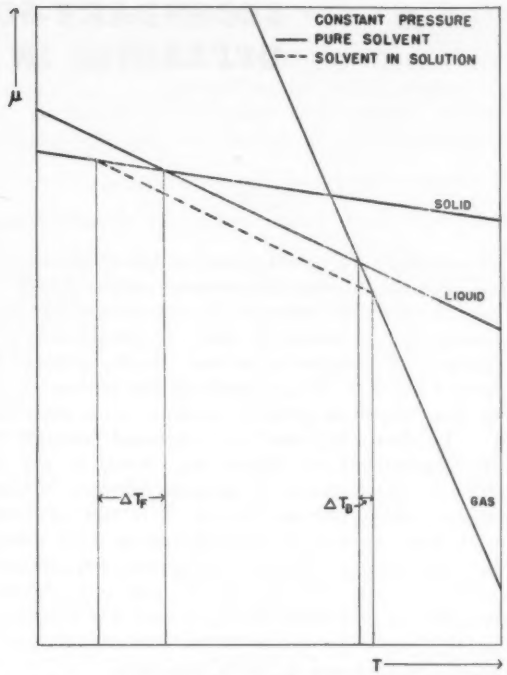

Figure 4. Isobaric Plot of Chemical Potential Versus Temperature for a Pure Solvent and for Solvent in an Ideal Liquid Solution

"Nature's great book is written in mathematical language."

Galileo, 1564–1642

SECONDARY-SCHOOL CHEMISTRY OFFERINGS IN OKLAHOMA

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THE emphasis in recent years on the motivation of senior high-school students toward careers based on chemistry raises the question of opportunity to study chemistry at the eleventh- and twelfth-grade levels. A survey of offerings in Oklahoma schools, initiated by request of the A. C. S. and made by the author for the three local sections, permits analysis on a statewide basis. Fundamental data were obtained through the State Department of Education. Analysis can be made for: (1) number of schools offering biology, chemistry, and physics as sciences; (2) number of classes of each science; and (3) enrollments in each science within the sample schools. Oklahoma requirements for graduation stipulate one year of a laboratory science, with option to substitute the third year of a vocational agriculture, or a vocational home economics, or of a vocational trades and industry program.

SCHOOLS OFFERING SCIENCE

Table 1 gives the number of schools offering any or all of the three sciences in the year 1953–54, distributed according to high-school enrollment. School offerings were obtained from a special postcard questionnaire and enrollments for approximately half of the schools returning answers were then taken from applications for accrediting. Only white public schools were included in order to utilize a pre-existing mailing list under pressure of a tight time schedule.

Table 1 shows the necessity of enrollment for supporting-science offerings. There is little reason why one of these sciences cannot be offered in schools having as few as 75 pupils. It is difficult for a school to maintain instruction in the second science unless the enrollment exceeds 150. It appears to require 200 or more pupils to warrant offering the third science. Approximately 60 per cent of the schools under 50 enrollment and not offering any of these sciences are dependent[1] schools.

In the ranking of individual sciences, biology outstrips the others, being offered in 215 of the total sample of 351 schools. Chemistry ranks second choice, being offered in 71 schools (20 per cent of sample) in comparison with 54 (or only 14 per cent) schools listing physics. When geology is offered it is confined to the very large high schools.

These data reflect the situation in one particular year. The size of figure will vary slightly from year to year especially among the smaller schools.

Offering science courses in a two-year cycle, usually alternating chemistry with biology, is a common practice in small and medium-sized schools for solving problems in costs, teacher availability, and student interest. Many (71) of the schools listed in this sample as offering none of these sciences in 1953–54 plan to offer a science (usually biology) in 1954–55. In some of the schools in the 101–300 enrollment classes, chemistry is alternated with physics, biology being given every year.

Examination of the data shows that school enrollment is a more influential factor than socio-economic condition. Greater than expected offerings occur in some communities of more limited resources and average years of schooling in the population. Offerings less than expected are reported from wealthier communities, primarily in the wheat-producing counties. A conscientious effort appears to be made by school administrators to meet the state requirement of one year of laboratory science. However, the combination of community conditions needed to bring chemistry into the curriculum seems to be related to (1) population density (measured by per cent of urban residents in the county) and (2) proximity to industrial activity or an academic institution. This warrants further exploration if we are to evaluate the influence of resource personnel.

FREQUENCY OF OFFERINGS

Opportunity to study chemistry is also reflected in the number of classes offered by the schools. With data missing from four large schools, it was found that 92 courses in chemistry were offered during the year in the schools of the state, and 228 courses in biology in the same schools. This gives biology an average advantage ratio of 2.4. However, this ratio increases with the size of the school, from 0.4 in schools of less than 150 total enrollment to 4.2 in schools of over 500.

STUDENT ENROLLMENT IN SCIENCE COURSES

Analysis of enrollments reveals the extent to which students avail themselves of the opportunities offered. Data are given in Table 2 covering more than 10,000 students enrolled in science courses in 80 schools which offer chemistry.

Whereas the ratio of number of classes in biology to chemistry is slightly less than 2.5, the ratio of actual

[1] Dependent school districts in Oklahoma are those which do not meet the requirement of independent schools in regard to size of faculty. Independent schools are defined by the State Board of Education as having eight or more full-time teachers.

enrollments exceeds 3.5. Student selection is accordingly less for chemistry than for biology. The pattern of increasing ratios of students taking biology and chemistry with school size appears to be influenced by several factors including: (1) the sizable number of small schools in which chemistry was the only science offered in the sample year; (2) the fact that nine administrators (10 per cent of sample) also taught chemistry in small schools; and (3) the less varied offerings in the curriculum.

The increase in the relative number of students taking physics in the larger schools indicates the ability of that science to compete for student attention better in the larger high schools. Of six schools where the physics enrollment is relatively high, and competitively strong, community factors are quite obvious. One school serves the wealthier part of a major city. Another school draws heavily from children of military personnel at a nearby post specializing in artillery. Two schools serve communities where petroleum refinery operations are strongly supported by research programs. The remaining two schools are in medium-sized cities where strong independent colleges influence the cultural outlook of the population. The teacher factor in this particular subsample is inconclusive in that in half of the schools the same teacher handles chemistry and physics. In the other half, different teachers present the two sciences.

Data at hand do not permit analysis of the teacher factor in the presentation of chemistry and biology. In schools where the same teacher handles both sciences, the ratio of enrollments (biology to chemistry) varies from 0.70 to 11.4. While the teacher's personality and reputation may be important in determining the extent to which chemistry will be elected by students, presence of other factors prevents quantitative determination of the effect from the present data. Among these other factors are: (1) the departure of male teachers from the profession during World War II; (2) the present availability of teachers; (3) the low replacement of science teachers trained in the past decade; and (4) the greater financial prospects in non-school work. This last factor alone operates against the schools' finding a sufficient supply of competent and qualified teachers.

IMPLICATIONS

This study was undertaken to gather comprehensive data describing the status of chemistry in one state's schools. It was part of a national survey requested by the leading professional organization to help determine facts. These findings may be presumed to be used for the revision of vocational guidance programs for students and for the extension of interest and support for teacher-improvement programs. As a part of a whole, the present study can be expected to vary quantitatively from those reported from other parts of the country.

Many factors are already known to have influenced the frequency of chemistry offerings over the years. Among these factors are: (1) the "eating of the seed" during World War II when many high-school, as well as college teachers migrated to industrial employment; (2) the shift in philosophy of secondary education around 1915 from the concept of college preparation of the able students to terminal schooling of all youth; and (3) the inroads upon student attention made by favorably supported vocational programs. Some attention should be given these if more effective counseling programs are to be developed. Better understanding by professional chemists participating in such programs is essential.

TABLE 1
Science Offerings Versus School Size: Number of Schools

H. S. enrollment	*No science*[a]	*Biol.*	*Biol., chem.*	*Biol., phys.*	*Biol., chem., phys.*	*Total*[b]
Under 51	23	16	0	0	0	39
51–75	18	12	0	0	0	30
76–100	7	11	1	0	0	19
101–150	2	21	5	2	0	30
151–200	1	5	11	1	1	19
201–300	0	6	5	5	6	22
301–400	0	0	4	0	2	6
401–500	0	0	2	0	6	8
Over 500	0	0	0	0	10	10
Total	51	71	28	8	25	183
Enrollment data missing	72	69	5	4	5	155

[a] No biology, physics, or chemistry.
[b] In addition, seven schools offer chemistry and six schools offer physics as the only science.

When professional chemists undertake to participate in a public relations role, they must remember that to most persons biology is the more available and/or familiar science. Attitudes toward chemistry are undoubtedly influenced by prior experience with biology, either personally or vicariously acquired.

Students study chemistry in all parts of the state. The data show a higher proportion (almost double) of students in small schools studying chemistry than in large schools. This raises questions about our assumptions concerning the origins of science and science-based majors now in college. Are the scientists of the

TABLE 2
Distribution of Students Among Science Courses

H. S. enrollment	*% students taking a science who take:*			*Av. ratio of enrollments*	
	Biol.	*Chem.*	*Phys.*	*Biol., chem.*	*Phys., chem.*
Under 201	54.4	44.6	1.0	1.22	0.024
201–300	67.2	30.4	2.3	2.21	0.078
301–400	79.2	16.5	4.3	4.78	0.25
401–500	72.4	18.1	9.5	4.00	0.52
Over 500	75.3	15.1	9.6	5.00	0.63
Over-all av.	72.4	20.1	7.4	3.60	0.37

future now coming from the semi-rural and middle-class origins in numbers comparable to those of the present and past generations of established scientists?[2] Or if the future group is not now coming from such environment, are we overlooking a potential source of students who could easily be encouraged in scientific pursuits? Could our recruiting and guidance efforts that are now directed toward urbanized youth be better directed toward the youth of semi-rural communities?

The proportionally larger number of students studying biology needs better understanding by those professional chemists volunteering for guidance counseling. Youth in rural areas might respond better to the challenge of a scientific career in chemistry than previously supposed. They might respond more readily than their sophisticated city cousins. And they might respond in numbers enough to provide that much needed supply of technical manpower. Can we afford to ignore the potential supply that exists in the less populated areas?

More problems have been uncovered than solved in this particular study. The data are sufficient for basing of college-professional school relations programs in this particular state. Comparison with similar characteristics of other states is highly desirable and necessary if the bias of this sample is to be eliminated from generalizations that might be misapplied to states of different socio-economic structures. But some of the findings that did not bear out preconceived or widely held conceptions could very well apply to other states.

[2] KNAPP, R. H., AND H. B. GOODRICH, "Origins of American Scientists," University of Chicago Press, Chicago, 1952, pp. 268–86.

GEMESIS

DIAMOND, the hardest thing on earth, has finally been synthesized. Credit for the final stages of development belongs to scientists of the General Electric Research Laboratory, who have successfully made small diamond crystals, expensive even by diamond standards but of potential interest to industry. Even more important is that the frontier of science has been pushed farther back by this achievement.

The first commercial synthetic gem was sapphire, made by Verneuil in 1900 by sifting aluminum oxide powder through an oxy-hydrogen flame. Verneuil's first stones were rubies (red sapphires), and were relatively expensive and time-consuming to make. By 1940, however, the process had been improved to where the Swiss were producing synthetic sapphire bearings for watches and instruments, for as little as eight cents each, at a rate measured in millions annually. Then U. S. industry had to set up its own production facilities, and by the end of World War II was producing at the rate of 1000 pounds of sapphire a month—the raw material for about two million jewels.

Markets for synthetic gem bearings are again dominated by the Swiss; U. S. producers have turned to other industrial applications for sapphire—phonograph needles, thread guides, ball points for pens, windows for light transmission, and supports for electronic tubes. There has been substantial progress in synthesizing gems for the consumer market; one manufacturer produces synthetic star rubies and star sapphires, duplicating these rare stones at about one tenth the cost of the natural gems. Synthetic emeralds, produced by a method known only to its inventor, sell for about a fifth of the cost of natural ones. The very perfection of the synthetic gems, however, is a disadvantage in the fine jewelry market; the greatest sales opportunities are in industry. If synthetic diamonds become available in quantity, their chief use will be to sharpen many types of grinding wheels and tungsten carbide cutting tools.

IMPORTS ESSENTIAL

Almost 14 million carats of industrial diamonds (worth some $45 million) were imported into the United States in 1954—about 85 per cent of world production. Diamonds occur in commercial quantities in only a few places; the foremost producers are the African mines, especially (for industrial diamonds) those of the Belgian Congo. Brazilian, Australian, Indian, and Russian fields lag far behind in importance.

In making diamonds, nature has two big advantages over man—the availability of high pressures deep in the earth's crust, and unlimited time. Laboratory production of diamonds was possible only after development of our understanding of the physical chemistry of crystals. For example, thermodynamic studies showed that, under ordinary conditions, diamond is a less stable form of carbon than graphite, and this situation would be reversed only at high pressure. Bridgman of Harvard showed that the graphite-carbon transformation could proceed only if very high temperatures were also provided.

The best estimates available a few years ago showed that diamond synthesis would require pressures above 300,000 pounds per square inch and temperatures around 3600° F. The practical problems of achieving such conditions were enormous. Much work had been done in steel "bomb" enclosures, but steel and most other metals lose strength rapidly as the temperature is raised, and it was virtually impossible to duplicate, at the surface of the earth, conditions established by nature farther down. The G.E. research program involved development of a reaction chamber that would be capable of withstanding 1.6 million p. s. i. at 5000° F. for several hours.

With such equipment available, new fields for research are opened. A wide range of organic and inorganic compounds exhibit variations in physical and chemical properties under extremely high pressures and temperatures. Some of the forms of matter produced under these conditions may turn out to be more important commercially than the diamonds recently announced.—*Reprinted from the Industrial Bulletin of Arthur D. Little, Inc.*

THE EARLY BACKGROUND OF CHEMISTRY IN SOUTH CAROLINA[1]

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EARLY settlers in American colonies carried out what we call chemical operations in producing such things as wood tar, potashes, bricks, glass, wine, salt, leather, and quicklime. The establishment of tanneries, breweries, brick kilns, fulling mills, distilleries, etc., in the northern colonies prior to the settlement of South Carolina marked the earliest beginnings of chemical industry in America.

In addition to necessary items like those mentioned, the processing of agricultural crops for export was another phase of chemical industry which had counterparts in all the colonies. Indigo production, for example, achieved local prominence.

Endeavors of this sort were encouraged by persons interested in developing South Carolina. As early as 1707 the manufacture of potash and saltpeter was encouraged in this province, and in 1733 Swiss settlers at Purrysburgh produced silk.

This paper will not discuss these topics, interesting though they are, but rather will deal with persons and chemistry of the late eighteenth and early nineteenth centuries.

Before the first chair to include chemistry was established at South Carolina College in 1811, there were about 20 American colleges in which this subject was taught. In the first American medical schools chemistry was recognized as a branch of the curriculum from the beginning, but it was taught, at first, in connection with pharmacy and materia medica and occasionally, in small faculties, along with anatomy and surgery. Physicians were the standard-bearers of chemistry in America. Two-thirds of the early teachers of chemistry (before 1811), from Maine to Georgia, had received medical training, and nearly two-thirds of these had been students of Joseph Black or his successor Thomas Hope, at Edinburgh.

Most of the men teaching chemistry and associated subjects in American colleges were very capable and versatile individuals of broad culture. Only a few of these teachers can, however, be considered to have contributed to the advancement of chemistry through individual investigation and research. Some of them achieved fame in other fields, such as general science, anatomy, surgery, mineralogy, and medical jurisprudence.

Laboratory facilities for experimental chemistry were very meager or nonexistent; apparatus was generally quite crude and limited in amount and variety. In those colleges where an attempt was made to teach chemistry it was by the lecture system, sometimes sparsely, and but rarely fully supplemented by demonstration experiments and sample specimens. Contemporaries have described these "bench" experiments as "entertaining," "neat," or "brilliant." But the students had no part in the experiments other than as witnesses. The first laboratory work for students was introduced by Dr. Maclean at the College of New Jersey in the nineteenth century (*ca.* 1804). This particular situation was not retrograde here in America. The early chemical laboratories in European colleges and universities were intended primarily for the preparative and research work of the professor in charge. In only a few instances up to 1810 were chemical laboratories abroad opened for regular instruction of undergraduate students.[2]

The textbooks and manuals used by American teachers of chemistry before 1811 were mostly reprints of European works. Sometimes these were augmented by the American editor.[3] Until the nineteenth century there were few works written for students by American authors; among these few were Rush's "Syllabus of a Course of Lectures on Chemistry" (Philadelphia, 1770; editions up to 1783), Mitchill's "Synopsis of Chemical Nomenclature and Arrangement" (New York, 1794), Woodhouse's "Young Chemist's Pocket Companion" (Philadelphia, 1797), and Jacob's "The Student's Chemical Pocket Companion" (Philadelphia, 1802).

[1] Presented before the Robert Wilson Medical History Club, Charleston, South Carolina, March 4, 1954.

[2] Lomonsow at St. Petersburg (1748), J. G. Gmelin, Jr., at Tübingen (1753), Gadolin at Åbo (*ca.* 1790), Lampadius at Freiburg (1796), and Stromeyer at Göttingen (1806) admitted undergraduates to regular laboratory work.[4] Thomas Thomson at Edinburgh and later (1817) at Glasgow also made laboratory work for his students a part of the regular course. The private laboratories of pharmacist-chemists like Vauquelin (Paris) and the student laboratories of pharmacy teachers like those of Trommsdorff (Erfurt) and Wiegleb (Langensalza) are in a different category.

[3] Before the day of copyrights the press prepared many reprints of foreign books. American editions sometimes appeared only a few weeks after their publication in Great Britain. Boerhaave, Macquer, Marggraf were authors recommended and available in British and French editions before the Revolution. By 1800 English translations of treatises by Scheele and Fourcroy and an American edition of Lavoisier's "Elements of Chemistry" had appeared. The British works by Bishop Watson, Priestley, and Nicholson, also issued prior to 1800, were not favored in this country as teaching texts. In the first decade of the nineteenth century British and American editions of textbooks by Chaptal, Parkinson, Accum, Henry, Black, Thomson, Parkes, and Mrs. Marcet became popular.

Dr. James Hutchinson, in 1792–93, was the first American to teach only chemistry. He died in the yellow-fever epidemic which swept Philadelphia in 1793. The date of 1795, when Dr. James Woodhouse took on the duties of the chair of chemistry at the University of Pennsylvania, is probably more significant as the time when the first professorship devoted solely to chemistry was established at an American institution of full collegiate grade.[4]

To come now to the local scene: The first proponent of chemistry to be introduced is Dr. Henry Moyes (1752–1807), a blind Scotchman who had studied at Edinburgh and was inspired by Joseph Black. He lectured on chemistry in Great Britain, from 1779–83, and then came to America for a lecture tour. In Boston, Providence, New York, and Philadelphia he attracted large audiences; his last series of lectures, in Philadelphia, dealt with the philosophy of chemistry and natural history. Sailing for Charleston, S. C., in March, 1786, he was well received and wrote to Dr. Benjamin Rush just before sailing back to London. These are his words:[5]

> I will give some account of my success in Charleston. On the 16th of March we sailed from Philadelphia, & after a most tremendous passage we arrived here on the 10th of April. A large packet of Introductory Letters procured me a polite reception, & altho' in the language of the Town every body is at present enjoying the Country Air, yet my Lecture Room is much frequented, & often displays around Three Hundred.... A few days ago the Thermometer rose to 85 degrees, & this morning we found ourselves very comfortably situated by a good Coal fire. It is these and similar changes in the Atmosphere that destroy the health of the Southern States...to Embark tomorrow morning... Charleston, May 24.

We find that Dr. Moyes' series of 12 lectures, held in the State House, dealt with subjects such as "Air, fire, light, electricity, vegetables, &c. &c." "A variety of experiments" were used to illustrate "the laws which regulate the material universe." Tickets for gentlemen were sold for one guinea; and half a guinea for ladies.[6]

The title of his third lecture "On the history and properties of factitious gasses, namely fixable air, inflammable air, nitrous air, phlogisticated air and dephlogisticated air"[7] was more strictly chemical than the others. These gases are now known as carbon dioxide, hydrogen, nitric oxide, nitrogen, and oxygen. The prevailing custom of that day was to incorporate topics of chemistry into natural philosophy or physics; accordingly, subjects like latent heat,[8] heat transmission, evaporation, light,[9] phosphorescence, the electrical fluid,[10] earthquakes,[11] and volcanoes were included in the lecture series.

"The natural history of the human mind, or the progress of man from rudeness to refinement" was the topic of a special "lecture for the benefit of the poor in the city of Charleston."[12] Dr. Moyes' humanitarianism led him to publish in the local newspaper[13] "instructions for recovering persons who may meet with accidents...to prevent being buried alive." Both Dr. Moyes and Dr. Rush of Philadelphia were much interested in disseminating these instructions to the American public.

Following this itinerant lecturer there were sporadic attempts at instruction in chemistry in Charleston in the 1790's and the first part of 1800. Charles Fraser in his "Reminiscences" mentions attempts at public lecturing by Doctors Chichester, Dickson, Prioleau, and Simons, and says, "But in no instance were those laudable undertakings properly encouraged."[14]

Dr. John Chichester was an Englishman who, for a short time, lectured on chemistry at the College of Charleston.[15] A notice in the newspaper[16] of November 22, 1793 says, "Dr. Chichester will begin a course of lectures in chymistry...on Monday the 7th of January next in the philosophical school...." These lectures were open to the public, for a fee. In this third year of its existence the local school was not an institution of full collegiate rank.[17]

Dr. Chichester had joined the Medical Society of

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[4] Others have designated Benjamin Rush or John Maclean as the first professor of chemistry alone. However, pharmacy instruction was included in the scope, although not in the title of Rush's chair at Philadelphia until 1789; then Caspar Wistar taught both chemistry *and* the institutes of medicine. When the University of Pennsylvania was reorganized in 1791, James Hutchinson taught chemistry *and* pharmacy until 1792, and chemistry alone only in 1792–93 when pharmacy was transferred to the chair of materia medica, held by S. P. Griffitts. John Maclean at the College of New Jersey in 1795 occupied the chair of chemistry *and* natural history, and two years later also took over the teaching of mathematics and natural philosophy.

[5] ARMSTRONG, E. V., AND C. K. DEISCHER, "Dr. Henry Moyes, Scotch chemist: His visit to America, 1785–1786," J. CHEM. EDUC., **24**, 169 (1947).

Dr. Moyes had come from London to New England before 1785. Named professor of natural philosophy and astronomy at Columbia College in 1784, "his lectures were so instructive and entertaining that men fought to gain admission to the auditorium and women fainted at the door." (LANGSTAFF, J. B., "Doctor Bard of Hyde Park," New York, **1942**, pp. 154, 310.)

[6] *Charleston Morning Post and Daily Advertiser*, April 18, **1786.**

[7] *Ibid.*, April 22, **1786.**

[8] *Ibid.*, April 25, **1786.**

[9] *Ibid.*, April 28, **1786.**

[10] *Ibid.*, May 1, **1786.**

[11] *Ibid.*, May 5, **1786.**

[12] *Ibid.*, May 12, **1786.**

[13] *Ibid.*, May 27 and June 1, **1786.**

[14] FRASER, CHARLES, "Reminiscences of Charleston," Charleston, **1854.**

[15] EASTERBY, J. H., "A History of the College of Charleston," Scribner Press, **1935.**

[16] *The City Gazette and Daily Advertiser*, Charleston, South Carolina.

[17] Higher education in South Carolina had a difficult time in getting started. Although an idea for a college can be traced back to 1707 it was not until 1785 that the legislature finally authorized three colleges for the state (one each for the upper, middle, and low country), and not until the 1820's did the College of Charleston really attain full collegiate status. The committee of the colonial assembly which reported (1770) one of the several plans that died aborning intended a chair of physick, anatomy, botany, and chemistry. If this had been adopted medical education would have begun some fifty years earlier than it did. Dr. Lewis Mottet's plan for a pharmaceutical institute, proposed a year earlier (1769), also failed to materialize.

South Carolina in 1794 and his knowledge of chemistry was probably the reason for his appointment (Nov. 1, 1799) to its committee "to ascertain the effects of the late practice of clarifying Gin with Sugar of Lead."[18]

Dr. Stephen Dickson must have been a very capable man. He flashed across the local scene like a brief, brilliant meteor. On July 1, 1799, he delivered his introductory lecture in a public course of chemistry in "Delorme's Great Room, No. 44 Broad Street."[19] The fee for this series of lectures was fifteen dollars. Dr. Dickson's obituary notice in the newspaper designated him "a Fellow of the College of Physicians of Ireland, State Physician of Ireland, and Professor of the Practice of Medicine in the University of Dublin" and says, "He informed, while he seemed to enquire, and charmed, while he conveyed instruction." On September 8 he died, after a short illness, "while engaged in pursuits calculated to infuse the highest kind of knowledge in the rising generation.... A man of science is snatched from Carolina."[20,21]

The first native Carolinians to appear in this chemical parade were also physicians; all three of them were born in 1776, an easy date to remember.

Philip G. Prioleau graduated M.D. at the University of Pennsylvania in 1798, just a year after Joseph Johnson had received his medical degree there also. Both had studied chemistry under Dr. James Woodhouse, the outstanding American chemist of his day; both were members of the Chemical Society of Philadelphia; both had prepared theses on the effects of chemical remedies—Dr. Johnson writing on "Carbonic acid gas or fixed air," Dr. Prioleau on the "Use of nitric and oxigenated muriatic acids."

The newer theories of chemistry advanced by the French school had made slight headway in Great Britain and America up to the late years of the eighteenth century. A prominent champion of the older phlogiston theory was the famous Joseph Priestley, who emigrated from England to Pennsylvania and was offered the chair of chemistry at the University of Pennsylvania. Fortunately, he declined the appointment and Dr. Benjamin Rush's young protégé James Woodhouse was elected instead. The young professor and the old exponent of phlogiston frequently differed in their interpretations of experimental data; however, they both stressed the experimental approach and thereby greatly added to the advancement of chemistry in our country.

The Chemical Society of Philadelphia was composed of a group of prominent chemists and students interested in this young science. Dr. Woodhouse was the guiding light of the group. A patriotic concern with the chemical resources of the United States led this "Chymical Society" to offer to analyze any ores or mineral specimens sent them for this purpose. And the Medical Society of South Carolina cooperated[22] by publishing a notice in the newspaper[23] inviting the public to respond to the offer. Dr. David Ramsay offered to receive and forward to Philadelphia any specimens and to communicate the results, free of charge. During the short active life of this Chemical Society of Philadelphia at least nine South Carolinians who were students at the University of Pennsylvania became members (1797–1803).

Although Dr. Prioleau was mentioned by Fraser[24] as one who attempted public lectures on chemistry, it was Dr. Joseph Johnson who maintained an active interest in chemical subjects for a much longer time. Perhaps his close daily association with chemicals in the drug store which he conducted for many years accounted for this steady interest. An advertisement of March 3, 1802[25] states that Johnson and Dunlap, at 5 Broad Street, "have just prepared the Oxigenated Marine Acid.[26] This discovery of Mr. Scheele is the most useful preparation yet known for removing stains, spots of ink, iron, writing, &c...for sale in phials with printed directions...." At this time, before the rise of a fine chemical or pharmaceutical chemical manufacturing industry, each apothecary had to prepare his own chemical derivatives and compounds and the laboratory of the pharmacy was the cradle in which the infant chemistry was rocked.

When the first examination was held for granting a license to practice pharmacy in South Carolina (Dec. 14, 1818), Dr. Johnson was one of the examiners and questioned the candidate on chemical preparations. In February, 1824, when the organization of a faculty for the Medical College of South Carolina was considered by the Medical Society, Joseph Johnson was responsible for having the proposed chair of pharmaceutical chemistry and pharmacy altered to that of chemistry and pharmacy,[27] a less restrictive designation with broader scope.

Dr. Benjamin B. Simons, the contemporary of Drs. Prioleau and Johnson, finished his collegiate education at the College of Rhode Island in 1796. This same year he went to Edinburgh to complete his medical and surgical education. There he became quite friendly with John Murray who later became Edinburgh's lecturer on chemistry, materia medica, and pharmacy.

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[18] Typescript copy of the minutes of the Medical Society of South Carolina, November 1, 1799.

Dr. Chichester's name was removed from the roll of the Medical Society when he left the state, in 1805.

[19] *The City Gazette and Daily Advertiser*, July 1, 1799, Charleston, South Carolina.

[20] *Ibid.*, September 10, 1799.

[21] His 12-year-old son, Stephen, Jr., died a week later, and his widow died of "epidemic fever" two weeks after her son. Probably all three had succumbed to the yellow fever which had become epidemic about mid-August and was particularly severe in 1799.

[22] Resolution of March 12, 1798. Minutes of the Medical Society of South Carolina.

[23] *The City Gazette and Daily Advertiser*, Charleston, South Carolina.

[24] FRASER, *loc. cit.*

[25] *The City Gazette and Daily Advertiser*, Charleston, South Carolina.

[26] *I.e.*, chlorine.

[27] Edmund Ravenel, who also obtained his M.D. from the University of Pennsylvania (in 1819), was elected to this chair.

Dr. Simons assisted John Bell, dissecting for his anatomical plates, wrote a treatise on the bones, and lectured students in special anatomy. At the same time he was an assiduous student of chemistry under Joseph Black's successor, Thomas C. Hope, who was a proponent of the "new" chemistry. After further study in London and Paris, Dr. Simons returned to Charleston and in 1801 began his practice.

He gave a public lecture on carbonic acid gas in 1802 (March 3), and his memorialist to the Medical Society[28] says his chemical lectures were "attended by the most intellectual of the Community, and received not only their approbation, but gained him much reputation."

A few months later Benjamin Simons published his plan for a private "School for Medical Students."[29] In addition to osteology, surgery, medicine, and materia medica, "The principles of Chemistry will be taught and illustrated with suitable experiments; he intends to annex to his chemistry that important branch denominated Pharmaceutical Chemistry, or the art of preparing the Chemical Medicines used in the practice of physic."

In January and again in March, 1803, Dr. Simons presented before the Medical Society of South Carolina portions of his "Essay on Pharmaceutical Operations in Chemistry." He was soon after elected lecturer to the Society.[30]

The esteem in which Dr. Benjamin Simons was held can be inferred from the fact that the first scientific journal of South Carolina, which started publication in 1825, the *Carolina Journal of Medicine, Science and Agriculture*, dedicated its first number to him.

The development of what came to be called "pneumatic" chemistry sprang from the fundamental work of Black, Priestley, Scheele, Lavoisier, and other famous chemists of the eighteenth century. Possible medical applications of the various "factitious" gases, notably oxygen, carbon dioxide, and nitrous oxide, were not long in being investigated.[31]

Humphry Davy, who was superintendent of Dr. Beddoes' Medical Pneumatic Institute in England, had experimented with nitrous oxide, "dephlogisticated nitrous gas" he called it, and Dr. Beddoes had published some of the effects from its inhalation as early as 1799. The *Medical Repository*, issued by Dr. S. L. Mitchill in New York, had reported these early English experiments in 1800 and 1801. Dr. James Woodhouse in Philadelphia carried out some experiments with nitrous oxide in the winter of 1806, and the varying reactions of his students are interestingly and amusingly recorded.[32] Thomas G. Prioleau of Charleston, who became the first dean of the Medical College of South Carolina, was one of these student volunteers. Benjamin Silliman, the professor of chemistry at Yale, had also performed similar experiments on volunteers. The curious and stimulating effects which produced exaggerated muscular activity, wild singing, etc., furnished entertaining diversions and several public lecturers used the phenomenon to draw audiences to their classes.

William Burgoyne, an Englishman who established himself as a druggist and apothecary in Charleston in the early nineteenth century, was one of the pioneer experimenters with "laughing gas" in South Carolina.

Medicinal use of water "impregnated with fixed air" became commonplace by the early nineteenth century. In Geneva, Switzerland, carbonated water was manufactured for sale as early as 1790. A decade later we find several Charleston drug stores selling apparatus or "Machines for impregnating water with fixed air." Such water was advertised as "known to be very beneficial in hot climates."[33]

The use of natural mineral waters for various ailments had long been favored by both laity and physicians. With increased knowledge of analytical methods, data on the mineral components of foreign and domestic springs had accumulated and it became possible to prepare artificial mineral waters which closely simulated those of the famous spas and springs. At the very beginning of the nineteenth century the manufacture of well known mineral waters had become established in Europe and soon thereafter American cities also had such manufactories.[34] Chalybeate waters for the relief of "female complaints" were hardest to prepare; but solution of adequate amounts of gas in the waters was the principal technical difficulty to be overcome. Charles D. Simons, a young chemist of Charleston, invented and patented (1810) an improved process for charging mineral waters with carbon dioxide.[35]

Charles Dewar Simons, an unusually talented young man, was a nephew of Dr. Benjamin B. Simons by whom he was instructed in chemistry. Without benefit of formal instruction in chemistry he advanced to the professorship of chemistry and natural philosophy in the College of South Carolina at Columbia, the first to hold this chair (1811).[36] His early and accidental death a few months after starting his course

[28] Typescript copy of the minutes of the Medical Society of South Carolina, Oct. 1, 1844.

[29] *The City Gazette and Daily Advertiser*, Charleston, South Carolina, July 22, 1802.

[30] Typescript copy of the minutes of the Medical Society of South Carolina Sept. 1, 1803.

[31] Dr. David Ramsay, in an address before the Medical Society of South Carolina, on Jan. 1, 1800, said: ". . . oxygen gas or vital air . . . [is] successfully employed in relieving some of the most obstinate diseases. The attention of medical men is now fixed on pneumatic medicine . . . time, experience and a farther application of elastic fluids, to medical purposes, shall throw more light on this novel subject. . . ." This address was published as "Improvements, Progress and State of Medicine in the Eighteenth Century," Charleston, 1800.

[32] *Medical Repository*, 2nd hex., 5, 281 (1808).

[33] *The City Gazette and Daily Advertiser*, Charleston, South Carolina, August 16, 1800.

[34] *E. g.*, New York, 1803; New Haven, 1806; Philadelphia, 1807; Charleston, 1810.

[35] Patent issued August 16, 1810, to C. D. Simons and J. J. Riondell for "aerating water."

[36] His successor as professor of chemistry and natural philosophy was the Charleston physician Edward D. Smith, who had been a student at the University of Pennsylvania under Dr. Woodhouse. Prior to 1811 the seniors at the College of South Carolina had received lectures on chemistry from Paul Perault, professor of mathematics and natural philosophy.

was greatly lamented as the loss of a promising scientist of superior ability.

In 1809 Charles D. Simons was the prime mover in organizing the Charleston Philosophical Society. The spark kindled by this group flamed through its successors, encouraging local scientific endeavors in the years ahead. It was in March, 1810, that Simons opened his "Mineral Water Manufactory," having devised a "new and improved plan, with which the Water is saturated in so short a time, that it may be constantly supplied, fresh prepared."[37] His process required 14 minutes instead of the usual 30 hours for complete saturation of the water. Mr. Simons requested the Medical Society to analyze his mineral water, and the committee appointed for this purpose (Drs. Johnson, Carandeffez, Magwood) reported their determination of the component parts by chemical tests. We infer that his plan to imitate the natural mineral spring waters was not a great financial success, despite its scientific merits and the approbation of the medical profession.

Professor Simons' work at the College of South Carolina was too brief to evaluate. That his plans embraced laboratory work as well as lectures is indicated by his request for $5000 to fit up a room for chemical experiments and for apparatus.

The establishment of formal instruction and the inauguration of a professorship in chemistry at the College of South Carolina marks the end of one era and the beginning of another period in the story of chemistry in South Carolina. In the next half century the names of Edward D. Smith, Thomas Cooper, Edmund Ravenel, Robert W. Gibbes, Charles U. Shepard, Lewis R. Gibbes, J. Lawrence Smith, St. Julien Ravenel, and Joseph Le Conte, among others, stand forth with many and varied achievements to their credit. Their interest in and association with chemistry and medicine mark them for further consideration.

[37] *The City Gazette and Daily Advertiser*, Charleston, South Carolina, March 28, 1810.

TECHNIQUE FOR PREPARING HAND-DRAWN LANTERN SLIDES

ARTHUR W. FAIRHALL
University of Washington, Seattle, Washington

For seminars and colloquia it is frequently necessary to display graphs and other data by means of a slide projector. The preparation of such slides by photographing inked drawings is usually time-consuming and expensive, and for many purposes seems hardly worth while. There are available materials for making slides called typewriter slides, using transparent plastic sheets and carbon paper, but their use for hand-made drawings is usually unsatisfactory because the pressure required to produce a sufficiently dark line results in tearing of the overlaying carbon paper and frequently of the plastic sheet also. This note concerns a simple way of overcoming this difficulty, and slides may be readily prepared of a quality limited only by the artistry of the person drawing them.

It is generally not possible to make an inked line directly on a plastic film. The ink will not adhere uniformly to the surface, resulting in a very uneven line. This difficulty may be readily overcome if the surface of the plastic sheet is first swabbed with alcohol containing two per cent acetone. The surface is altered so that one may draw on it with India ink as readily as on paper. The effect persists long enough that one can usually complete a slide before the surface again takes on its nonretentive character.

As well as ease of drawing, this method has other advantages. One may readily make an erasure by simply wiping away the ink with an alcohol-soaked swab. Furthermore, any color of ink may be used, so that one may emphasize particular features of a given set of data by means of different colored inks, which are readily visible on the projected image because of their transparency.

The author has used this technique on a number of occasions using polystyrene film, and has found the results to be very satisfactory.

Report of the

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS

OFFICAL BUSINESS

280th MEETING

The 280th meeting of the NEACT was held on April 23, 1955, at Mount Holyoke College, South Hadley, Massachusetts. This was a special day at Mount Holyoke because their new Cleveland Hall and the Chemistry Laboratory were being dedicated. NEACT members appreciate having been invited to hold the April meeting in conjunction with the dedicatory exercises. One hundred twelve members and guests attended the NEACT program.

The meeting was opened by Roswell G. Ham, president of Mount Holyoke, who extended the hospitality of the college to NEACT members. In his address he expressed grave concern over the future of science and technology in America, because of the failure of the schools and colleges to turn out a sufficient number of science graduates, and especially graduates interested in teaching science.

The first speaker was Sister Marie Clare Markham of the chemistry department, Saint Joseph College, who spoke on the subject, "Photocatalytic properties of oxides," in which she brought in something from her own research, which has been conducted with help from undergraduate chemistry majors in her classes.

The second speaker was Marshall J. Walker, assistant professor of physics, University of Connecticut. His topic was "Education toward the universal mind." Dr. Walker feels that American education is lagging far behind English and European education in intensity. He believes that an accelerated program in the secondary schools, particularly in mathematics, would prepare the very able student for a really intensive study of the sciences in college.[1]

Graduate students conducted small groups through the new chemistry laboratory. Members were impressed not only with new equipment and laboratories, but also with the large amount of space available for chemical research. Mount Holyoke now seems ready for a sizable expansion in chemistry enrollment.

An excellent luncheon was served by the ladies of the First Congregational Church at South Hadley.

The third speaker was Linus Pauling, Nobel-prize winner in chemistry for 1954, who spoke on "Chemistry in relation to medicine." This address was given in Chapin Auditorium which was filled with Mount Holyoke alumnae and students, A. C. S. members, and NEACT members. Dr. Pauling, as usual, infected the audience with his own enthusiasm, and maintained high interest throughout his description of the rather complicated molecular diseases of human hemoglobin.

Marco H. Scheer, vice-president of the Association, conducted the business meeting.

The secretary welcomed the following new members into the Association:

Samuel R. Powell, Chemistry and Physics Teacher, Suffield Academy, Suffield, Connecticut
Edward A. Shore, Chemistry Teacher, Putney School, Putney, Vermont
Robert J. Thoren, Chemistry Instructor, Lyman Hall High School, Wallingford, Connecticut
John deMetropolis, Teacher of Science, Enfield High School, Thompsonville, Connecticut
Edward F. deVillafranca, Chemistry Teacher, Kent School, Kent, Connecticut
Philip B. Weld, Instructor in Physics and Chemistry, Phillips Academy, Andover, Massachusetts

It was voted to send a note of thanks to Mount Holyoke College for the hospitality of the day, and to the ladies of the First Congregational Church for the luncheon they served.

281st MEETING

The 281st meeting of the NEACT was held at Framingham State Teachers College, Framingham Centre, Massachusetts, May 14, 1955. Martin O'Connor, president of the college, told of the recent centennial celebration of the college in which it was noted that Framingham is the oldest normal school in America, having been founded by Horace Mann in 1839. He pointed out that teachers are the first line of defense in a democracy, and applauded efforts being made to return to the teacher his dignity and status in the community.

Albert Frost of Versenes, Incorporated, Framingham, Massachusetts, discussed the formation and behavior of chelating agents and their applications in such fields as analytical work and industrial operations, as biologicals, pharmaceuticals, etc. His demonstrations effectively illustrated several of these reactions.

The second speaker, Henry W. Kruschwitz, Metal Hydrides, Inc., Beverly, Massachusetts, described the

[1] *Cf.* WALKER, M. J., *J. Higher Educ.*, **8**, 417 (1954); also J. CHEM. EDUC., **31**, 617 (1954).

manufacture of metal hydrides and their practical uses. Relatively new compounds, the alkali-metal alumino- and borohydrides, are especially valuable as reducing agents in organic reactions.

A delicious lunch was served to the 60 members present by the home economics department of the college.

Charles N. Satterfield, department of chemical engineering, Massachusetts Institute of Technology, in his talk on hydrogen peroxide, spoke first of the problem of finding stabilizers to prevent its decomposition when handled and stored. He described the various methods by which hydrogen peroxide is manufactured in the United States and Germany and surveyed its uses from bleaching to the production of energy by exothermic decomposition and in support of combustion in rockets.

The business meeting was conducted by John A. Timm, president of NEACT.

The secretary welcomed the following new members into the Association:

Carolyn H. Kendrow, Instructor in Chemistry, University of Massachusetts, Amherst, Massachusetts

Wildrid J. Laliberte, Acting Head of Chemistry and Physics Department, Pawtucket West Senior High, Pawtucket, Rhode Island

Laurence S. Foster reported on plans of the various sections of the American Chemical Society in the New England Area to provide financial assistance to high-school teachers early in their careers to encourage them to attend the next summer conference. A similar NEACT award had been made possible by the generosity of David L. Davidson, Technical Operations, Inc., Arlington, Massachusetts. Dr. Foster announced for the Executive Committee that the recipient is John H. Walters, Jr., Browne and Nichols School, Cambridge, Massachusetts.

It was voted to send our thanks to the Framingham State Teachers College for their work in making the 281st meeting a success.

Immediately following the business meeting, the Annual Meeting was convened.

LEALLYN B. CLAPP, *Secretary*

ANNUAL MEETING

Framingham State Teachers College, Framingham Centre, Massachusetts, May 14, 1955. The following reports were accepted:

Secretary's Report

The Sixteenth Summer Conference was held at the University of Massachusetts, Amherst, Massachusetts, with Robert D. Eddy and Edward L. Haenisch as co-chairmen. Five meetings were held during the year, as follows:

277th: New Hampton School, New Hampton, New Hampshire, October 9, 1954—41 attending;

278th: Wentworth Institute, Boston, Massachusetts, December 4, 1954—106 attending;

279th: Mitchell College, New London, Connecticut, February 12, 1955—46 attending;

280th: Mt. Holyoke College, So. Hadley, Massachusetts, April 23, 1955—112 attending;

281st: Framingham Teachers College, Framingham, Massachusetts, May 14, 1955—58 attending.

Membership Committee.

Suspended on January 1, 1955		48
Dropped	15	
Reinstated	23	
Resigned	10	
New Members		46
Joining at summer conference	7	
High school	24	
College	22	

Total Membership, May 15, 1955: 568

LEALLYN B. CLAPP, *Secretary*

Trustees of the Endowment Fund

Treasurer's Report.

Balance, May 7, 1954	$2484.99
Income credited in the period May 7, 1954, through May 6, 1955	
Watertown Federal Savings and Loan Association	28.75
Newton Savings Bank	41.73
Two per cent of dues, 1953–54	$45.68
	$2601.15
Investments, May 6, 1955	
Five matured shares, Watertown Federal Savings and Loan Association, at cost	$ 994.91
Balance in the Newton Savings Bank, May 6, 1955	$1606.24
	$2601.15

AVERY A. ASHDOWN, *Treasurer, Trustees, Permanent Trust Fund*

Report of the Curator

Only routine duties have been performed by the curator during the past year. These duties have included:

(1) Maintenance of the permanent file of members. It should be noted that, prior to the annual meeting of 1955, 1989 members have been elected to the Association since its founding in 1898.

(2) Maintenance of a file of publications and such other materials about the activities of the Association as may have historical value.

(3) Preparation of addressed, stamped envelopes for use by the division chairmen and by the summer conference committee for publicity mailings.

RALPH E. KEIRSTEAD, *Curator*

Ralph Keirstead also reported that the constitution was being revised and amendments would be published in the next *Newsletter* for approval of the members at the adjourned annual meeting in August.

Report of The Editor of the *Report*

At the end of the current year in June, the *Report* of the NEACT will have completed its fifty-fifth year of continuous publication. The curator has a complete set of these records, and a complete set of the *Report* is on file at the Wesleyan University Library. Other libraries have nearly complete sets. At the present time, we are receiving 35 collected, paper-bound reprints of each year's *Report* to preserve in the archives and in these selected university repositories. In addition, the Association receives yearly two bound volumes of THIS JOURNAL which includes the *Report*. It has been the policy of the secretary and of the editor to include in the "official business" issues of the *Report* all important items that should be preserved in the Association's records.

The *Newsletter* has an important but more ephemeral purpose. It reports some items worthy of permanent record, but these usually are also repeated in the official *Report*. Mostly, it

Velmar Studio (*Nashua, New Hampshire*)

Marco H. Scheer

serves to inform the members of coming meetings and of current happenings. The *Newsletter* is now completing its ninth year as a supplement to the *Report*. Two copies are filed by the curator but no other official collection is maintained.

The *Report* has appeared monthly in THIS JOURNAL this year and the *Newsletter* will have its usual five issues. The June issue will conclude items about today's meeting.

It has been voted by the Executive Committee to separate the two records of the Association's activities. The *Report* will continue to appear in THIS JOURNAL under the supervision of the current editor.

It is now the pleasure of the Executive Committee to announce that Seward E. Beacom, Teachers College of Connecticut, New Britain, has agreed to serve as editor of the *Newsletter*, beginning next year. He will be assisted by Mahlon F. Hayden, science teacher at Bulkeley High School, Hartford, who has accepted the assistant editorship in place of Eva M. Ruggli who has served so ably during the past few years.

In spite of having been a NEACT member for only a short while, Seward Beacom (Beac) is already well known to NEACT and particularly to members in Connecticut, where he has become identified with activities of the Connecticut Science Teachers Association. He was chairman of the first Northern Connecticut Science Fair in 1949 and has maintained an active interest in such undertakings. After graduating from Mount Union College, Alliance, Ohio, in 1934, he taught at several high schools in the state of New York. He joined the faculty of the University of Michigan in 1944, received his M.S. degree in analytical chemistry from Michigan in 1946, and in 1948 accepted his present appointment at New Britain, where he is associate professor. Last year he completed his doctorate at the University of Connecticut. In addition to teaching, he has had industrial chemistry experience at U. S. Gypsum, Chevrolet Motor and Axle Co., Union Carbide and Carbon Research Laboratories, and at the Stanley Works in New Britain.

Mahlon F. Hayden (Mike) was graduated from Williams College in 1952, after some years in the U. S. Army. He received the MAT degree from Yale in 1953, and now teaches chemistry and physics at Bulkeley High School. He and Beac have great plans for the *Newsletter* and request the cooperation of members in furnishing material for use in it. The Association is fortunate in the way its members pitch in to carry out its various activities and it is now apparent that under the new regime the *Newsletter* is launched auspiciously as an even more important means of communication among the members.

It is fitting to recognize the very great help which has been given by Eva M. Ruggli in preparing the rough drafts of each issue of the *Newsletter* and her enthusiastic culling of the New York Times for timely items for inclusion. Also, it is a pleasure to acknowledge the continued cooperation of the chemistry staff of the Massachusetts College of Pharmacy who have volunteered to mimeograph, assemble, staple, fold, and mail each issue of the *Newsletter* as a service gladly performed for the Association.

LAURENCE S. FOSTER, *Editor of the Report*

Report of the Committee on Honorary Members

The following two members were nominated for honorary membership and elected unanimously at the Annual Meeting:

INA M. GRANARA, a member of this Association since 1933, its devoted servant on many committees, a chairman of a highly successful summer conference, and a competent division chairman; champion of progressive, but rigorous teaching of chemistry in the councils of this Association and of the American Chemical Society; lively and inspiring teacher of chemistry at her Alma Mater for 30 years; beloved by all who know her for her vivacious personality, her gracious presence, and her adherence to a stern code of personal and professional ethics.

DOROTHY WESTGATE GIFFORD, member of this Association since 1929, leading architect of its structure and program since 1942 as division chairman, secretary, vice-president, and president; enthusiastic teacher of secondary-school science for more than 30 years; a vigorous proponent of science, properly taught, as a tool for developing the disciplined mind; proudly recognized by her Alma Mater as one of its outstanding graduates; admirer of the natural beauty of the world around her to which she seeks to add through researches in the hybridizing of iris; facile of wit, lucid in expression, cogent in argument, wise in council; deeply respected for her fidelity to friends and family, revered for the way in which she has made her quiet Quaker faith a guide to all her acts.

RALPH E. KEIRSTEAD, *for the Honorary Membership Committee*

Member of Nominating Committee. The president called for candidates to replace the retiring member of the nominating committee. Walter G. Stewart, Springfield College, Springfield, Massachusetts, was elected.

Report of the Nominating Committee

President—Marco H. Scheer, Nashua High School, Nashua, New Hampshire

Vice-president—Robert D. Eddy, Tufts University, Medford, Massachusetts

Secretary—Leallyn B. Clapp, Brown University, Providence, Rhode Island

Treasurer—Carroll B. Gustafson, Massachusetts College of Pharmacy, Boston, Massachusetts

Chairman of Northern Division—Lorne F. Lea, St. Paul's School, Concord, New Hampshire

Chairman of Central Division—Dorothy Abel, Brookline High School, Brookline, Massachusetts
Chairman of Southern Division—Evelyn L. Murdock, Stonington High School, Stonington, Connecticut
Chairman of Western Division—E. Harold Coburn, Bulkeley High School, Hartford, Connecticut
Auditor—S. Walter Hoyt, Belmont, Massachusetts
Curator—Ralph E. Keirstead, Dept. of Education, State of Connecticut, Hartford, Connecticut
Member Endowment Fund Committee—Elbert C. Weaver, Phillips Academy, Andover, Massachusetts

HELEN W. CRAWLEY, *Acting Chairman*

The secretary was instructed to cast one ballot for the slate of officers.

A vote of thanks was taken for John A. Timm's work as president during the past year by the new president, Marco H. Scheer, and the meeting was adjourned *sine die*.

MARCO H. SCHEER was born in Manchester, New Hampshire, on December 31, 1918. He received his early education in the public schools of that city, graduating from Manchester High School West in 1936. He was graduated from Tufts College with a B.S. (biochemistry) in 1940, and in 1949 received his M.Ed. from the University of New Hampshire. In 1946 he was awarded a General Electric Science Fellowship at Union College, Schenectady, New York, and has also done work at Lowell Textile Institute.

He has been a member of the NEACT since 1944, and has served as chairman of the Northern Division (1950–52), co-chairman of the Fourteenth Summer Conference (1952), and vice-president (1954–55). He also holds membership in the National Science Teachers Association, Kappa Delta Pi (Honorary Society in Education), and the American Chemical Society. In addition he is a member and has held office in state and local educational organizations.

Since 1942 he has been teacher of chemistry at Nashua High School, New Hampshire, and has also been instructor in chemistry at the Nashua Memorial Hospital, as well as a member of the Nursing School Committee there.

Since 1951 a part-time interest has been the renovation and rejuvination of his newly purchased home. He has been active in The First Congregational Church in Nashua, serving as sunday-school superintendent and member of the Committee on Religious Education, and is currently on the Board of Deacons.

• TITANIUM IN INDUSTRY

***Stanley Abkowitz, John J. Burke,* and *Ralph H. Hiltz, Jr.*, Watertown Arsenal Laboratory. D. Van Nostrand Co., Inc., New York, 1955. x + 224 pp. 16 × 24 cm. $5.**

DURING the past five years the chemistry of titanium has been brought up to date by the publication of Jelks Barkdale's "Titanium" (THIS JOURNAL, **27**, 290 (1950)), Gmelins "Handbuch, System 41, Titan" (THIS JOURNAL, **30**, 537 (1953)), and Skinner, Johnston, and Becket's "Titanium and its Compounds" (THIS JOURNAL, **31**, 615 (1954)). Each of these recent books was necessarily deficient in that little attention was paid to the metallurgy and fabrication of titanium and its alloys. This omission was excusable, of course, because the metallurgy had not yet been worked out and published at the time of writing. The exponential growth of metallic titanium production is unparalleled in the history of metallurgy. From a production of a few pounds in 1945, two tons in 1947, 500 tons in 1951, 5000 tons in 1954, and a predicted production of 35,000 tons in 1956, titanium has suddenly become a commercially available structural metal. Simultaneous with the rapid expansion of production facilities there has been a tremendous effort expended on alloy development and on fabrication techniques. The present volume was written by three young scientists who have been close to these developments and it attempts to fill the gap left in the previous treatises.

Taking up where the other books left off, this new, brief volume discusses industrial production of the metal; alloying and heat treatment; fabrication procedures; methods of joining, machining, and grinding; corrosion resistance; and surface coatings. One section summarizes methods for chemical analysis and for metallographic examination of alloy structures. The final chapter, which is necessarily short, is concerned with specific applications for titanium and its alloys. So rapid is the progress, however, that in the next few years one may confidently expect to see a great extension in their adoption for all kinds of uses.

The brief review of the chemistry of titanium in Chapter 2 is unexpectedly naive and unsophisticated. It is regrettable that an otherwise competent book is marred by such statements as: "The widest range of compounds occurs in the tetravalent state, but all compounds can be formed in each of the valence states." Titanium dioxide is ignored in: "The metal combines with oxygen to form a long series of oxides from TiO to Ti_7O_{12}, each of which exhibits a different hue, and, at short time exposures, a rainbow-colored surface film is produced." The free halogens and the hydrogen-halogen acids are confused with halides in: "The most rapid reaction is again with the fluoride." Meaningless statements are made, like: "Other inorganic acids have a negative attack on the metal, and, as yet, none of these has found application in the industry." The authors are urged to revise this section completely in future editions. On the other hand, the review of chemical analytical procedures and of metal-

lographic techniques in Chapter 9 is thorough and accurate. The analytical procedures are, however, merely outlined and no references are given. The metallographic techniques are given in great detail, but again without literature references.

Titanium alloys have the high strength and ductility of alloy steels (at least up to 200,000 p. s. i.), give better corrosion resistance than stainless steel, and offer a saving in weight of 44 per cent, but applications are still hampered by the continuing high cost. When the remaining difficulties encountered in mass production of tititium have been conquered, the application of titanium and of tananium alloys "will be limited only by man's imagination."

LAURENCE S. FOSTER

BELMONT, MASSACHUSETTS

● CELLULAR METABOLISM AND INFECTIONS

Symposium held at the New York Academy of Medicine, March, 1954. Edited by *E. Racker.* Academic Press, Inc., New York, 1954. xi + 196 pp. Figs. and tables. 16 × 23.5 cm. $4.80.

THE book contains discussions from 16 investigators in the United States, and one from H. A. Krebs of England, with a final summary by A. Lwoff of France. The author index has citations from approximately 500 investigators. A subject index of approximately 500 major entries with many more subheadings covers 11 pages. These figures indicate the usefulness of the book as a work of reference. However, certain topics such as acute leukemias of children, occupying considerable space in the text, appear to be omitted from the index. Part I, by seven authors, including an informal discussion by them and two guests, is on "Aspects of comparative biochemistry," and Part II is on "Metabolic aspects of the infectious process." The informal discussion stresses viewpoints of two schools of thought by the advocates of "unity in biochemistry"—the "unitarians"—and of "disunity in biochemistry," respectively. The excellent chapter by Krebs emphasizes the first concept and the chapter by Stanier, on dynamic systems in bacteria, and the chapter by Bueding on differences between *Ascaris* and schistosomes contain evidences of the second concept.

Part II deals with a considerable number of toxin-producing bacteria, fungi, and protozoa, such as the agents of diphtheria, *Fusarium*-wilt of tomato plants, and malaria; also with a number of "phages" and of other viruses causing disorders of various kinds such as avian erythromyeloblastic leukosis and "wild fire" disease of tobacco. As pointed out by Racker the viruses are living organisms in the sense that they possess a genetic apparatus that functions in survival, but do not have any enzyme systems producing utilizable energy. Like the agents of tuberculosis, leprosy, and certain other diseases, the viruses exert their effects intracellularly in connection with the genetic apparatus of the host cells.

Most of the discussions emphasize differences of infective agents *in vitro* and *in vivo*, particularly the formidable nature of problems of a rational chemotherapy. However, a considerable number of instances are cited wherein toxins and/or antimetabolites have been demonstrable. As pointed out in the chapter by Welch, the data relating chemical structure to biological activity are impressive. For example "A-methopterin" affords temporary relief in cases of acute leukemia in children, and chloroguanide (Paludrine) and pyrimethamine ("Daraprim") affect the metabolism of species of *Plasmodium in vivo*. The first of these agents inhibits the enzyme system which forms citrovorum factor from folic acid, and the last two may serve as inhibitors of utilization by plasmodia of compounds of the "folic acid series." As explained by Pappenheimer and emphasized in a discussion by Wooley, the toxins and factors which overcome their effects have been found for a wilting disease of tomatoes and "wild fire" disease of tobacco. The temporary effects of some of these drugs were explained as mutations of the causative agents, but Davis cast doubt on the assumption that a single mutation could account for the gradual manifestations of resistance.

After reading and abstracting each chapter of the book this reviewer has found it impossible in the limited space allotted to give more than a sketchy account of its contents. However, seldom has he found so much information in so few pages, and does not hesitate to recommend the text to biologists as a means of broadening their horizons.

CHARLES W. REES

NATIONAL INSTITUTES OF HEALTH
BETHESDA, MARYLAND

● ANNUAL REVIEW OF PHYSICAL CHEMISTRY. VOLUME 5: 1954

Edited by *G. K. Rollefson* and *R. E. Powell,* University of California. Annual Reviews, Inc., Stanford, California, 1954. x + 540 pp. 16 × 23 cm. $7.

VOLUME 5 of this well known review lives up to the standards of previous volumes. Topics covered and authors are as follows: "Thermochemistry and thermodynamic properties of substances," L. E. Steiner; "Heterogeneous equilibria and phase diagrams," W. A. Gale; "Solutions of electrolytes," H. S. Frank and M.-S. Tsao; "Solutions of nonelectrolytes," J. C. Morrow and O. K. Rice; "Isotopes," W. M. Jones; "Radioactivity and nuclear structure," I. Perlman and J. M. Hollander; "Radiation chemistry," E. J. Hart; "Theory of molecular structure and spectra," A. D. Walsh; "Spectroscopy," A. B. F. Duncan; "The solid state," R. H. Bube, F. Herman, and H. W. Leverenz; "Kinetics of reactions in solution," F. A. Long; "Kinetics of reactions in gases," J. C. Robb; "Properties of macromolecules in solution," F. T. Wall and L. A. Hiller, Jr.; "Colloid chemistry (exclusive of high polymers)," S. A. Troelstra; "Cryogenics," E. A. Long and L. Meyer; "Nuclear magnetic resonance," H. S. Gutowsky; "Crystallography," E. G. Cox; "Surface chemistry and catalysis," G. Jura; "The microwave spectra of gases," R. J. Myers and W. D. Gwinn; "Experimental molecular structure," R. L. Livingston; "Ion exchange," J. Schubert; "Statistical mechanics of transport and nonequilibrium processes," E. W. Montroll and M. S. Green; "Modern aspects of electrode kinetics," J. O'M. Bockris.

As usual, every chapter is a mine of information, and a time saver of inestimable value for every worker in the many fields represented.

P. W. SELWOOD

NORTHWESTERN UNIVERSITY
EVANSTON, ILLINOIS

● CHEMICAL PROCESS PRINCIPLES. PART I: MATERIAL AND ENERGY BALANCES

Olaf A. Hougen, Professor of Chemical Engineering, University of Wisconsin, _Kenneth M. Watson,_ Vice-president and Director of Research, Pure Oil Company, and _Roland A. Ragatz,_ Professor of Chemical Engineering, University of Wisconsin. Second edition. John Wiley & Sons, Inc., New York, 1954. xxxv + 504 pp. 129 figs. 39 tables. 15 × 23.5 cm. $8.50.

STARTING with "Industrial Chemical Calculations" in 1931, "Hougen and Watson" has undergone a complete rearrangement and rewriting in each edition. In 1943 the name was changed to "Chemical Process Principles," and the book was issued in three parts: I, Material and Energy Balances; II, Thermodynamics; and III, Kinetics and Catalysis. These books were enthusiastically received by both the teacher, who used them as the basis of courses in chemical engineering, and by the practicing engineer, who used them to modernize his education and as reference texts in the process fields.

This new edition represents a complete rewriting of the previous Part I. Professor R. A. Ragatz has become a coauthor. Now the book begins with a chapter on mathematical pro-

cedures which emphasizes graphical methods and particularly the use of triangular diagrams. The second chapter on stoiciometric and composition relationships introduces the mole method of chemical calculations. Chapter 3 applies the ideal gas laws and mole method to gases.

Physical chemistry is introduced in liberal quantities beginning with the forth chapter on vapor pressure. The student is immediately confronted by a Lennard-Jones 6-12 equation which is used to explain liquefaction and vaporization. Vapor-pressure plots, like the Cox chart, Dühring and Othmer plots, are presented. In order to use generalized vapor-pressure equations, critical properties and the law of corresponding states are discussed. Considerable space is devoted to the calculation of critical properties by an unpublished method due to Lydersen which is based on group contributions. The following chapter on humidity and saturation is changed but little from the previous editions.

Extensive changes have been made in the chapter on solubility and crystallization. In addition to the crystallization calculations for inorganic salts in water, methods for extraction calculations are given. This includes the Ponchon diagram for solvent extraction. The section previously devoted to sorption is expanded into a new chapter on adsorption. Not only are types of adsorption explained but the calculations of adsorption and desorption and their thermal effects are given.

The important chapters on thermophysics and thermochemistry are replete with new data taken largely from N.B.S. and A.P.I. sources. Because of its continued use in U. S. Bureau of Mines publications, the heat-capacity equation of Maier and Kelley might have been shown. Considerable new material on thermochemistry has been added and the chapter appropriately closes with the most powerful thermal process—nuclear reactions.

The last two chapters represent the applications of the physical-chemical principles to industrial processes, first to fuels and combustion, and then to chemical, metallurgical, and petroleum processes. All illustrated problems have been reworked using the new thermochemical data. New petroleum problems, including a fluid catalytic cracking unit, are included.

Every chemical engineer who must make process calculations will need a copy of this revised Part I, and will watch for the revisions of Parts II and III. With a background in physical chemistry, the chemist can study the illustrated problems and then apply the methods to his process calculations. For the student of chemical engineering it is desirable that a course in physical chemistry precede the study of "C.P.P.," though the book is self-sufficient and an instructor can teach the material without reference to other courses. Many new problems are given and now answers are given for about half of them.

This is the kind of a book that every chemical engineer will need in his future work, so he might as well become acquainted with it during his school days.

KENNETH A. KOBE

UNIVERSITY OF TEXAS
AUSTIN, TEXAS

● STATISTICS FOR TECHNOLOGISTS

C. G. *Paradine*, Senior Lecturer in Mathematics at Battersea Polytechnic, and *B. H. P. Rivett*, Head of Field Investigation Group, National Coal Board, England. D. Van Nostrand Company, Inc., New York, 1953. viii + 288 pp. 14.5 × 22.5 cm. $6.75.

THE authors of this book have perceived that most of the applications of statistics in research and industry are made by individuals without formal training in statistics. The avowed purpose is to make available more of the underlying theory of probability and mathematics than is given in many of the books currently available. The usual point is made that users of statistical formulas will do a better job if they understand the assumptions back of the formulas. This is certainly a reasonable attitude to take. On the other hand, this book demonstrates that even authors who undertake to show others how to *derive* statistical formulas apparently do not always understand how to *use* them.

One of the most common and important statistical tests is the comparison of variances. On page 114 the usual F-test for the comparison of two estimates of the variance is given. Reference is made to the usual F-table but no hint given that the table gives a one-tail test. The ratio of the larger estimate to the smaller, when the data determine which estimate is larger, is a two-tail test.

This blunder appears again in the chapter on the analysis of variance. The example on page 233 concerns a simple two-way table: ten operators on each of five machines. This example gives a residual mean square (for error) considerably larger than the mean squares for machines and operators. The F ratios are computed by putting the error variance in the numerator simply because it is the larger number. The authors do not take up the question as to the interpretation to be made if this ratio had proved significant. It would be hard to find "cookbook practitioners" of statistics that go astray in this manner.

The sections on probability and on theory are satisfactory. The book reflects inexperience in applications. Example 5 on page 168 is worth mentioning. "A large set of numbers have all been rounded off to the second place of decimals. The mean of n of these numbers is calculated. What is the least value of n for which the mean can be given to two decimal places with probability 99% of being correct?" By the usual convention, one number, rounded off to two places, is correct to two places by definition. The authors give n as 220. Besides the numerical slip in the computation as given, the problem, as set, requires considerable interpretation.

W. J. YOUDEN

NATIONAL BUREAU OF STANDARDS
WASHINGTON, D. C.

● THE HARVEY LECTURES, 1953–54

***Claude Fromageot, Hans H. Weber, David Nachmansohn, Paul Klemperer, Rollin D. Hotchkiss, Britton Chance, Albert L. Lehninger, Linus Pauling,* and *James D. Hardy.* Academic Press, Inc., New York, 1955. viii + 299 pp. 115 figs. 14 × 21 cm. $7.50.**

THE lectures cover a wide array of topics and are all of a uniformly high standard as can be expected from the distinguished scientists selected as speakers. Fromageot discusses sulfur metabolism, stressing the importance and fate of cysteine sulfinic acid in intermediate sufur metabolism. Weber, whose chapter was to this reviewer one of the high lights of the book, shows by means of ingenious experiments that the provision of sufficient ATP brings about the movements of various cells as well as the contraction of smooth or striated muscles, even if their metabolism has been largely stopped. Nachmansohn has a readable chapter on metabolism and function of the nerve cell, emphasizing the acetyl choline system. It is of interest to note that much of the advance in this field came from the study of the giant nerve fibers of the squid and the electrical organs of fish, experimental animals all too frequently neglected by "classical" physiologists. Klemperer, in a largely historical chapter, reviews the significance of the intermediate substances of the connective tissues in human disease, while Hotchkiss deals with the recent developments on genetic chemistry of pneumococcal transformations. Chance describes enzymes in action in living cells, summarizing experiments made possible largely by his genius for instrumentation. Lehninger discusses in a very clear fashion a timely topic to which he has contributed many fundamental data himself: oxidative phosphorylation. Pauling contributes a chapter on abnormal hemoglobin molecules in hereditary hemolytic anemias, the contributions of his laboratory to the sickle-cell problem helping to elucidate a complex problem. The last chapter is written by Hardy and deals with the regulation of the body temperature. It is of special interest to the comparative physiologist because of the use of various laboratory animals. The unexpected fact

emerges that the dog rather than the monkey is the better experimental animal for a study of the factors involved in human heat regulation.

Owing to the variety of topics discussed and the excellent standard of the contributions, this book should appeal to a wide range of readers: biochemists, physiologists (both of the mammalian and comparative brand), geneticists, microbiologists, and physicians. It contains many beautifully reproduced illustrations, but lacks any kind of an index.

THEODOR VON BRAND

National Institutes of Health
Bethesda, Maryland

● TWO EARS OF CORN, TWO BLADES OF GRASS

D. H. Killeffer. **D. Van Nostrand Company, Inc., New York, 1955. x + 139 pp. 15.5 × 23.5 cm. $4.**

Here is a book about the wonders of modern chemistry by a distinguished author, editor, and chemical engineer. He shows how the scientific know-how of chemists working through industry is able to produce the necessities of life. He skilfully portrays how man has mastered chemical synthesis, fear of famine, conquest of disease, and atomic fires, and developed new practices for growing foodstuffs, and technological processes which mine the sea as well as the good earth. He encourages us to train our sights on an abundant peaceful future based on the application of science to human needs, and encourages us to share our scientific knowledge, for he feels that this, more than anything else, can overcome the causes of war, depression, and human suffering. In his preface he writes: "Creative ability is our most precious possession. . . . Stimulating and activating the creative powers of all people puts into a nation the means to satisfy its own aspiration and clearly avoid the covetous thirst for possession and power that appear as universal causes of human conflicts and wars." Dr. Killeffer fills us with a confident hope of peace if people everywhere use what they know how to do well. People with good minds, however, are needed for the kind of work that develops these chemical products that mean so much to humanity. He points out that industry today offers opportunities to young men and women to carve out such careers. Dr. Killeffer illustrates his theme with more than 30 halftones and anecdotes. He himself is the holder of some 14 patents.

GRETA OPPE

Ball High School
Galveston, Texas

● MAIN CURRENTS OF SCIENTIFIC THOUGHT: A HISTORY OF THE SCIENCES

S. F. Mason. **Abelard-Schuman, Inc., New York, 1954. viii + 520 pp. 16 × 24 cm. $5.**

"Science is a human activity developing an historically cumulative body of interrelated techniques, empirical knowledge, and theories, referring to the natural world" (p. 488). The author exhibits the development of science, the interrelation of its techniques, knowledge, and theories. He emphasizes both the influence of scientific achievements on society and the effect of the fashions and values of a period or society on the progress of science. Science, although rooted in the development of craft skills in the Bronze Age and in the technical innovations of subsequent centuries, is a recent development of history. Nevertheless, Dr. Mason says, it has influenced personal relationships and modern behavior in that we are perhaps more inclined than our forbears to rely on rational arguments rather than emotional appeals, to decide between rival viewpoints on the basis of empirical evidence.

When an author attempts to discuss the trends of scientific thinking from prehistoric times to the present in 494 pages of text, it may be unfair to criticize him for omissions. With approximately 900 entries in the Index of Names it is evident that only passing mention is made of many of these scientists. However, the book does not purport to be a biographical collection. Although the development of instruments and of experimental techniques has had significant influence on the advancement of science, neither is adequately discussed. Presumably, one studies history to understand the present and to gain an insight into the future; here, for example, to understand the relations between modern science and philosophy, or the reputed conflicts between science and philosophy, or the reputed conflicts between science and religion or ethics, or science and the arts, or to assess the impact of the natural sciences on the social sciences. The author has little to say about these matters. Perhaps, however, some of them are discussed in the bibliography of about 250 references.

WALTER B. KEIGHTON

Swarthmore College
Swarthmore, Pennsylvania

● INDUSTRIAL DETERGENCY

Edited by *Wm. W. Niven, Jr.*, Manager, Chemical Engineering Division, Midwest Research Institute. Reinhold Publishing Corp., New York, 1955. 340 pp. Illustrated. 15.5 × 23.5 cm. $8.75.

The editor and six other contributors discuss practical detergent problems as encountered in the following industries: laundry, drycleaning, textile processing, food and beverage, dairy, dishwashing, and metal processing. Principles and detergent materials are also discussed, as well as industrial cleaning problems in general.

Much of the discussion of hard water has appeared in other reference books and might therefore have been condensed further. An excellent presentation of various types of syndet is given, with graphic representations which show at a glance the chemical nature of a typical molecule of each. Correlation with commercial products is made by listing one or more of these with each chemical type.

The specific detergent problems of each industry considered are discussed in more or less detail, particularly in terms of the kind of detergent needed, equipment available for its application, and the direction in which improvement might occur.

Minor criticisms are of such items as Figure 3-7. This gives comparative properties including detergency, wetting power, emulsifying power, corrosiveness, etc., of caustic soda and a number of alkaline salts, without reference to any substrate. A highly important factor in detergency is the nature of the material being cleaned. How can one say that caustic soda is a better detergent than soda ash but poorer than trisodium phosphate? What substrate is corroded? It seems as though the author has attempted to generalize where no generalization is possible.

In Table 3-11, the column headed "Solvency" presumably refers to ability to dissolve fats; it would be better to make the heading more specific.

Original articles may be consulted for further details by use of the footnotes. The book is of particular value because of its consideration of practical industrial cleaning problems.

CORNELIA T. SNELL

Foster D. Snell, Inc.
New York, N. Y.

● PRINCIPLES OF EMULSION TECHNOLOGY

Paul Becher, **Senior Project Chemist, Colgate-Palmolive Company. Reinhold Publishing Corp., New York, 1955. ix + 149 pp. Figs. and tables. 12 × 17.5 cm. $2.95.**

Carries the discussion of general principles a little beyond that of the general course, with emphasis upon practical considerations.

Out of the Editor's Basket

Midget Laboratory Mill

Development of a small, lightweight, all stainless steel mill to answer the needs of general research has been announced by Morehouse-Cowles Industries, Inc., 1150 San Fernando Rd., Los Angeles 66, California, manufacturer of high-speed stone milling equipment.

Wide Range Pressure Gauge

Scientific Glass Apparatus Co. Inc., Bloomfield, New Jersey, has just announced the development of a new Zimmerli Gauge known as the "Wide Range" model, making a total of five Zimmerli Gauges now in the line.

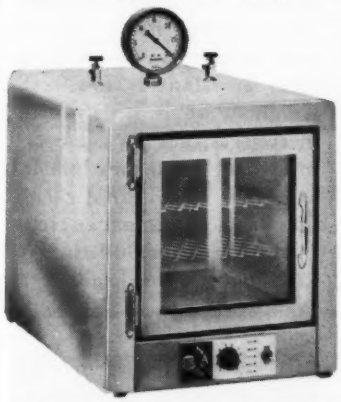
The "Wide Range" is intended for pressure up to 370 mm. Hg above atmospheric and for the full barometric range of reduced pressures.

Variable Speed Stirrer

A new small, compact variable speed stirrer, Model #101, is now available in the T-line of high quality stirrers made by Talboys Instrument Corp. of Emerson, New Jersey.

Vacuum Oven

A new vacuum oven for laboratory use has just been announced by National Appliance Company. The unit features large capacity with full visibility. Radiant heat provides room to 140 °C within ±0.5 °C.



An illustrated circular giving details of construction and price may be had by writing to National Appliance Company, 7634 S.W. Capitol Highway, Portland 19, Oregon.

Sonic Analyzer

The E-Scope is a sonic analyzer for nondestructive testing of solid and viscoelastic materials, features unusual accuracy, portability and operating convenience in providing measurement of effects of natural or induced deterioration, flaws or inclusions, or product uniformity. It is a self-contained instrument designed for laboratory use, field testing or production quality control.

A comprehensive bulletin and bibliography may be obtained from manufacturer, Kinetic Instrument Co., Highland Park, Illinois.

Automatic Burette

A new automatic burette, designed to simplify laboratory work, has been announced by Meyer Scientific Supply Co., Inc., 1672 62nd St., Brooklyn 4, New York. The new burette is supplied with a squeezable reservoir bottle for convenient buret filling with automatic finding of zero point.

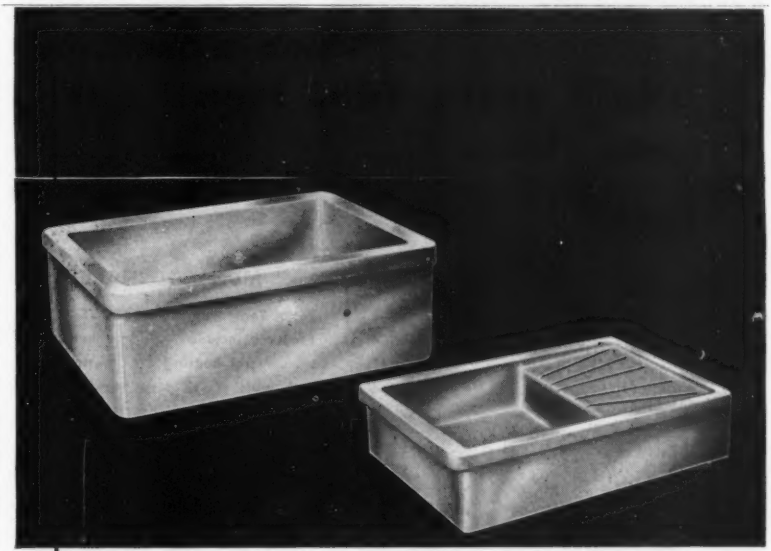
Combination Magnetic Stirrer and Hot Plate

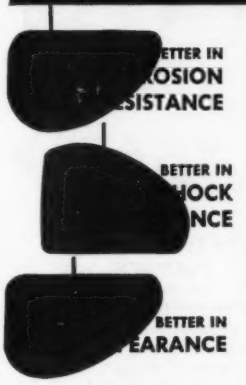
Stirring and heating in one time-saving operation can now be performed efficiently with the new Will Combination Magnetic Stirrer and Hot Plate, manufactured by Will Corporation, Rochester, New York. Stirrer and heater will also function separately if desired.

Unlike conventional magnetic stirrers, the Will utilizes a pulley and belt drive to rotate the permanent Alnico magnet, thus affording the widest possible range of stirring speeds.

Mercury Diffusion Pump

Delmar Scientific Laboratories announces the new Delmar-Van Hespen 2-stage Mercury Diffusion Pump. The new





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It is a beautiful sink. Trim in design, with smooth, rounded corners, inside and out. Its lustrous, blue-gray glaze is an integral part of the porcelain body — can never peel or flake off, and is as easy to clean as a china dish.

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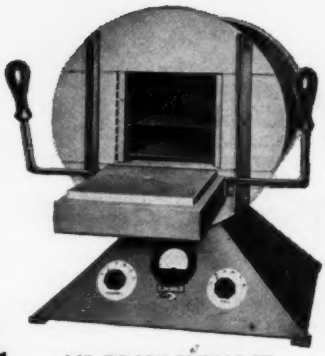
Used for melting small quantities of metals. Maximum temperature 1950° F. Five standard sizes. Other types available for 2300° F. operation.



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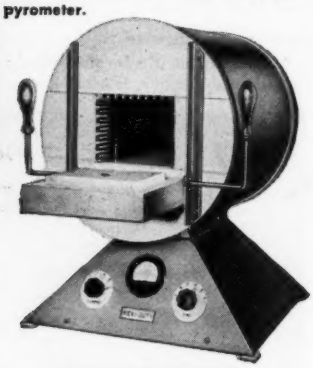

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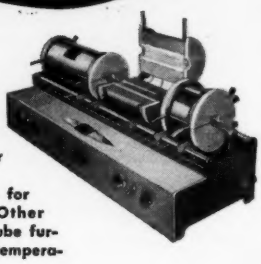
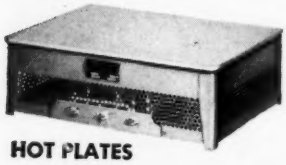
Three separately controlled tube furnaces mounted on slide rails, for use individually or as one assembly. Hinged construction for easy operation. Other sizes and types of tube furnaces available for temperatures to 2600° F.





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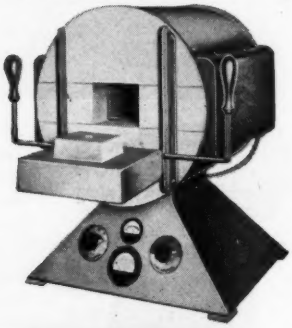
7 Standard sizes, each with 3 heat control. Temperatures to 750° F.



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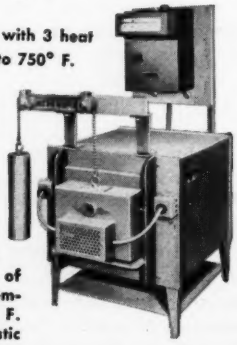

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Vapor Equivalent Apparatus

An instrument designed for more rapid and easier determinations of vapor equivalent in residues from natural gas samples, or of any liquid with a vapor pressure of more than 4 mm. at the temperature of the vaporization bulb, is announced by Central Scientific Company, 1700 Irving Park Rd. Chicago, Illinois.

The new Vapor Equivalent Apparatus, which also determines molecular weights, is capable of measuring the volume of vapor produced by a unit volume of liquid in approximately 10 minutes, a fraction of the time required by the former, cumbersome Victor-Meyer method.

Thermo Balance

Burrell Corporation, 2223 Fifth Ave., Pittsburgh 19, Pennsylvania has announced a new Stanton Thermo Balance for laboratory technicians. The instrument provides combined heating and weighing of materials under test and furnishes a continuous, permanent, visual pen record of all changes.

Applications in the field of gravimetric analysis are almost unlimited. "Heat to constant weight" can be determined easily in research or for control of processes. Other uses include determinations of moisture, volatile and ash; the preparation of oxidation curves and evaporation rates; carbon and sulfur determinations; atomic weights; reagent purities and many others. The recording cycle may be changed to suit varying applications.

Vapor Fractometer

The Vapor Fractometer, a simple, low-cost, portable apparatus for the analysis of multi-component mixtures of gases or volatile liquids, is now in production by The Perkin-Elmer Corporation of Norwalk, Connecticut. A powerful analytical tool, the new apparatus is based on the principle of gas chromatography and utilizes the fractional separation of vapors by means of a partition column.

This type of apparatus will find use wherever mixtures of gases or low boiling liquids are analyzed routinely. The method may also be used for the separation of unknown components from a mixture which can then be qualitatively analyzed by infrared or mass spectroscopy, or other means. Time for analysis varies from 1/2 to 5 minutes per component. Reproducibility is better than 1/2 per cent.

Scintillation Spectrometer

Atomic Instrument Company, 84 Massachusetts Ave., Cambridge 39, Massachusetts announces the Model 513 Single Channel Scintillation Spectrometer, a complete system designed for precision analysis of various gamma-emitting radioisotopes, whether they occur singly or in mixtures or compounds. The Model 513 is a complete assembly, requiring no extra equipment for use. It is designed for use by personnel not familiar with ordinary scintillation equipment.

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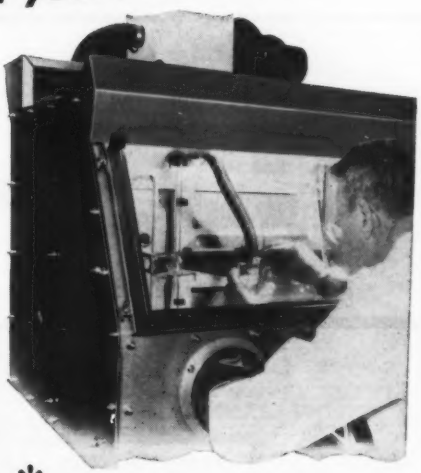

* Chemical Biological Radiological

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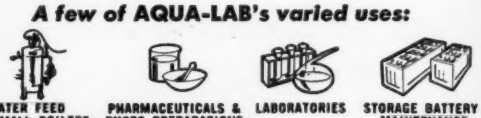

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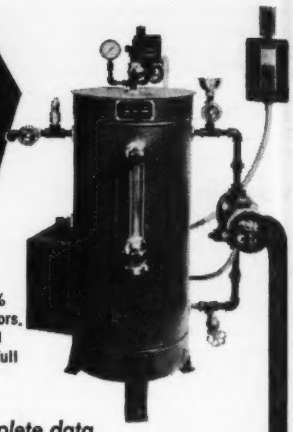

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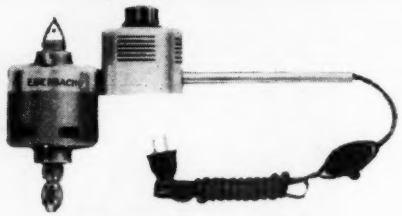

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Write for Bulletin 440-H

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● A new pH indicator which shows a pink-to-blue color change at pH 8.2 that is said to be easier to observe than the subtle end-point of phenolphthalein is included on the latest list of additions to the 3500-odd Eastman Organic Chemicals.

Designated 4,4′-Bis(4-amino-1-naphthylazo)2,2′-stilbenedisulfonic Acid, the reagent has been recommended for the so-called "phenolphthalein" alkalinity determination in water testing.

Other compounds newly available from Eastman Organic Chemicals Department, Distillation Products Industries, Rochester 3, New York, are the following: 3-Benzoylacrylic Acid (Pract.) MP 91–94° $C_6H_5COCH{:}CHCOOH$...MW 176.17; Bis(alpha-methylbenzyl) Ether (Pract.) BP 146–150°/8 mm. $[C_6H_5CH(CH_3)]_2O$... MW 226.32; cis-1,2-Dichloroethylene BP 59–60° CHCl:CHCl...MW 96.95; trans-1,2-Dichloroethylene BP 48–50° CHCl:CHCl...MW 96.95; 1,6-Hexanediamine Dihydrochloride $NH_2(CH_2)_6NH_2{\cdot}2HCl$... MW 189.14; 1,6-Hexanediol MP 40–42° $HO(CH_2)_6OH$...MW 118.18; N-(2-Hydroxyethyl)-2-phenoxyacetamide MP 48–51° $C_6H_5OCH_2CONHCH_2CH_2OH$...MW 195.22; Oxybis(2-ethylbenzoate) (Pract.) BP 225–227°/3 mm. $C_6H_5COOCH_2CH_2OCH_2CH_2OCOC_6H_4$...MW 314.34; 1,2,-3,4-Tetrabromobutane MP 115–118° $CH_2BrCHBrCHBrCH_2Br$...MW 373.76.

NEW LITERATURE

● A new eight-page brochure on the several types of recording spectrophotometers manufactured by Beckman is just off the press. Written to assist the prospective purchaser of recording spectrophotometers, this booklet details the requirements for a variety of quantitative and qualitative applications and recommends the particular type of instrument for each use. Request *Bulletin 405* from Beckman Division, Beckman Instruments, Inc., Fullerton, California.

● Materials and methods for stabilizing vinyl resins are described in a 24-page technical bulletin, *Witco Stayrite, Stabilizers for Vinyl Resins* newly published by the Witco Chemical Co., 122 E. 42nd St., New York.

The booklet states that there is presently no universal stabilizer for vinyl resins and analyzes the factors which enter into individual stabilizing problems.

Unstabilized vinyls have a tendency to darken in color when exposed to heat and ultra-violet rays. The function of stabilizers is to prevent or minimize deterioration from these or other causes. The booklet explains that in some cases use of more than one stabilizer is advisable and lists the stayrites applicable to meet various requirements.

Fourteen different stabilizers, of the cadmium-barium, synergist, non-toxic, lead, cadmium, and barium types are described.

● Andrew Technical Supply Co., 6972 N. Clark St., Chicago 26, Illinois, have a pamphlet out on their equipment and devices on items of special interest to engineering, processing, inspection and testing laboratories.

● The Bulletin 551, April 1955, of A. Daigger & Co., Kinzie at Wells, Chicago 10, Illinois, presents an *Apparatus Digest* of apparatus and equipment for research, testing and laboratory control.

● Schaar & Co., 754 Lexington St., Chicago 7, Illinois, present in their May 1955 *LABoratory* a variety of apparatus and equipment available for the scientific laboratory.

● Baker & Adamson, General Chemical Division, Allied Chemical & Dye Corp., 40 Rector St., New York, 6, New York, has issued a 1955 edition of *Laboratory Reagents and Fine Chemicals*. Listings include approximately 1000 products, information on hazardous items, labeling, packaging, storage and handling as well as specifications.

● Its 48-page general catalogue, illustrating and describing its complete line of polyethylene and polyvinyl chloride fabricated products, plates, sheets, rods tubes, pipes and fittings, and hot gas welding and spraying equipment is now available from the American Agile Corporation, P. O. Box 168, Bedford, Ohio.

● Newly revised to include up-to-the minute information of value to chemists,

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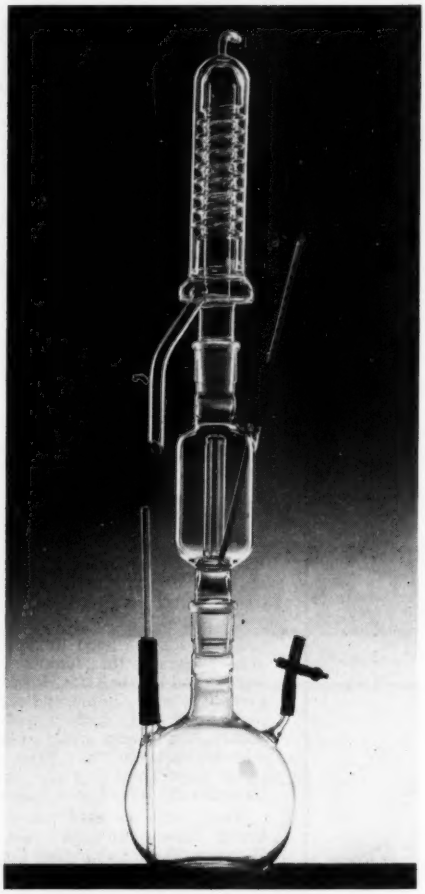

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chemical engineers, and purchasing agents, the product catalogue just issued by Eastman Chemical Products, Inc. of Kingsport, Tennessee is certain to become a "reference shelf" guide among the industries served by the company.

● A new 6-page, 2 color brochure describing the Model 13-U Universal Spectrophotometer has just been published by The Perkin-Elmer Corporation, Norwalk, Connecticut. The brochure describes and illustrates the operation of the Model 13-U over the infrared, near infrared, visible, and ultraviolet ranges. Typical spectra illustrate its performance. Complete specifications and description of accessories are also included.

● *Labaratus*, a new catalogue supplement, has been issued by Central Scientific Company. The 64-page booklet lists 350 of the company's manufactured and specialty instruments, including a current price list. Photographs and descriptions of new and improved products are presented throughout the book.

Copies may be obtained by writing to Central Scientific Company, 1700 Irving Park Rd., Chicago, Illinois.

● A new 28-page catalogue, No. AW13, is now available from Wm. Ainsworth & Sons, Inc., Denver 5, Colorado. It includes complete information on their new Right-A-Weigh one-pan balance; micro, semimicro, analytical and assay balances; equipment for balances; balance accessories and parts; and weights. Also included is a table of the National Bureau of Standards' new tolerances for individual weights and group tolerances for weights in sets.

● Bulletin describes Electrothermal heating tapes that can be wound around laboratory glassware or metallic industrial equipment. For copies, write to Arthur S. LaPine & Company, 6001 South Knox Ave., Chicago 29, Illinois.

● *Get Perfect Water Clarity with Celite Filtration* is the title of a new 12-page, illustrated brochure by Johns-Manville, 22 East 40th St., New York 16, N. Y. It covers filtration of potable water, process water, and plant wastes.

The brochure explains how Celite diatomite filter aids remove colloids and other suspended impurities; shows the adaptability of Celite powders to various types of filter designs; and, cites representative installation where Celite is being used to advantage.

● A revised and expanded technical bulletin which offers step-by-step directions for six *Analytical Methods for Pentachlorophenol and Its Salts* has been published by Monsanto Chemical Company's Organic Chemicals Division, St. Louis 4, Missouri.

● A booklet on *Petrothene* polyethylene resins for plastics molders and extruders has just been issued by U. S. Industrial Chemicals Co., Division of National Distillers Products Corporation, 99 Park Ave., New York 16, New York.

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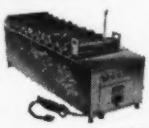

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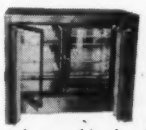

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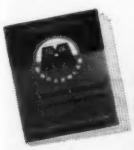

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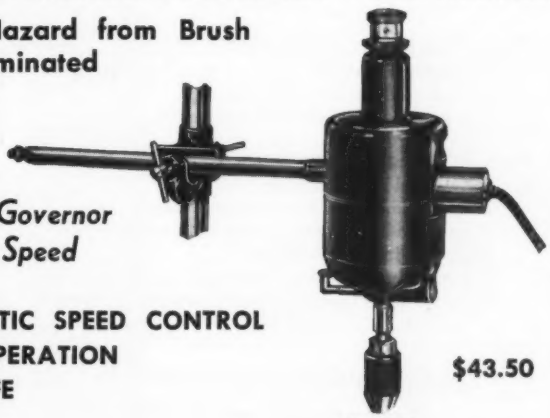

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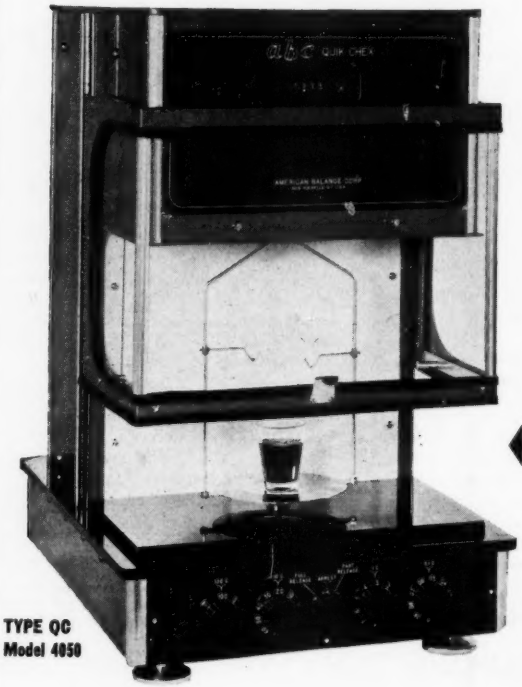

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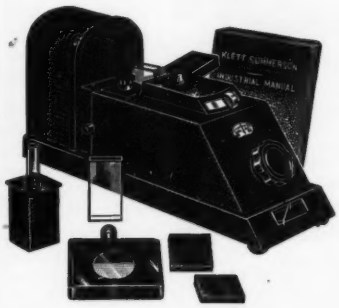

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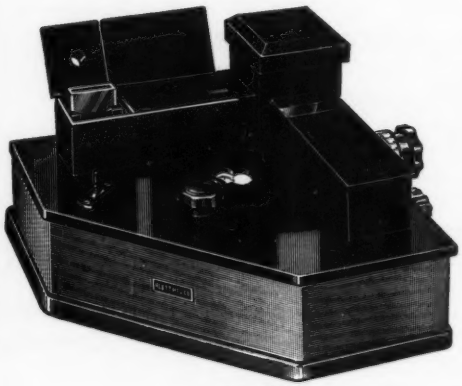

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● Tempil Corporation, 132 West 22nd St., New York 11, New York, has a new leaflet on their 400° Temp-Alarm° GA-1 temperature sensitive paint, which undergoes a dramatic color change from mustard yellow to maroon in five minutes. Samples are available without charge, on request.

● An eight-page bulletin, prepared by Kontes Glass Co., describes recently modified precision stirrer assemblies. Large size and stainless steel stirrers have been introduced as well as various accessories including stirrer motors. To aid in the selection of correct replacement parts a "Table of Stirrer Parts" is given. Write to Kontes Glass Co., Vineland, New Jersey, for *Bulletin PS-1.*

● An important new international journal has recently appeared, the *Journal of Inorganic and Nuclear Chemistry*, with an impressive board of editors and advisors. The establishment of such a journal is the obvious culmination of advances during the last two decades in this important field. The first number contains contributions in English, German, and French, from a number of internationally known workers in the field. The publisher is Pergamon Press, Inc., 122 E. 55th St., New York 22, New York.

● A new booklet of "calm musings" about some of the 3,500 organic chemicals available in limited quantities for science and industry from Distillation Products Industries, a division of Eastman Kodak, is now being distributed under the title *More Tales from the Alembic.*

The new publication is a sequel to *Tales from the Alembic* published two years ago. Contents range from the story of Squalene, a derivative of basking shark liver which is described as a "fascinating hydrocarbon," to Guanine Hydrochloride and to Tetrabromophenolphthalein Ethyl Ester. Also included is a card with which abstracts and research papers describing the chemicals and samples of the chemicals themselves may be ordered.

Copies of *More Tales from the Alembic* may be obtained without charge from the Eastman Organic Chemicals Department, Distillation Products Industries, Rochester 3, New York.

MISCELLANY

★ The April-May, 1955, issue of The DuPont Magazine contains several interesting articles, one especially for the chemist "Save Your Antifreeze?" Well—

★ The March 1955 issue of *The Unesco Courier* is devoted to the subject of "Atomic Power" and is worthy of your consideration. This $2.50 a year journal is published by The Department of Mass Communication of UNESCO, United Nations Building, New York 17, New York.

★ *ARDC Intensifies Search For Innovations.*—Do you have an idea for a new missile? Or a new principle which might revolutionize aircraft design? Or a raw material which can stand temperatures that turn ordinary metals to liquid?

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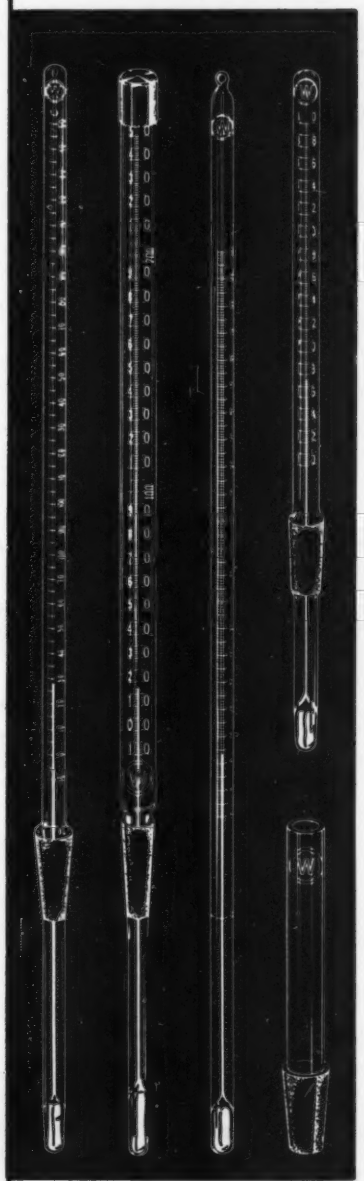

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(SEE FIG. 1)

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5"	3.60	4.20	4.60	4.85
6"	3.80	4.55	4.85	5.10
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5"	6.15	6.50	6.95
6"	6.45	6.75	7.20
7½"	6.70	7.05	7.50
8½"	7.00	7.30	7.75
10"	7.25	7.60	8.05
11"	7.80	8.15	8.60

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By Cecil E. Boord, *The Ohio State University,* Wallace R. Brode, *National Bureau of Standards, and* Roy G. Bossert, *Ohio Wesleyan University.* New edition features added exercises on aliphatic compounds. *1955. Approx. 332 pages. $3.90.*

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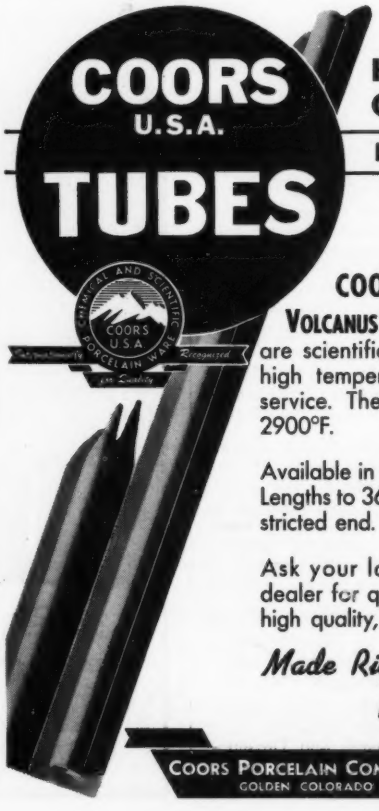

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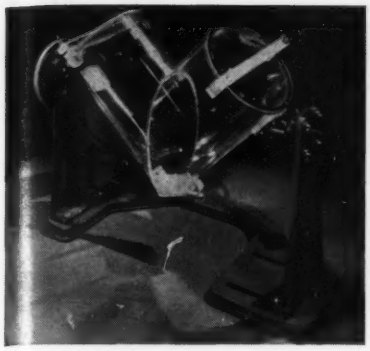

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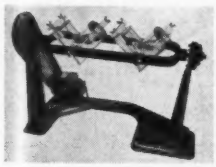

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Highlighting the increased search for new ideas, the Command's Analysis and Evaluation Office has appointed an Assistant for Innovations. This post, held by Lt. Col. M. W. Beardsley, is the focal point for receiving and studying ideas from industry, universities, and private individuals engaged in research work.

Correspondence to ARDC should be addressed to the Assistant for Innovations, RDTE, Headquarters, Air Research & Development Command, Box 1395, Baltimore 3, Maryland.

★ Do you want some excellent information on tape recording and sound track manufacturing operations? See *Esso Oilways*, April, 1955.

★ L. R. Kleinschmidt of The National Bureau of Standards recently developed a simple inexpensive chromatographic fractionation method for separating asphalt into four groups of components having different physical characteristics, in studying the weather resistance of asphalts.

★ The rapid development of fluorescence microscopy is due to the fact that it enables unstained and unfixed, *i. e.*, perfectly natural tissues to be rendered visible in their finest structural details and with the maximum of clarity. However, it has extended far beyond the bounds of vital microscopy into other branches of science and technology, and also industry; *i. e.*, chemistry and mineralogy, the textile and paper industries, criminology, and the foodstuffs testing laboratories. For further information write: Wm. J. Hacker & Co., Inc., 82 Beaver St., New York 5, New York.

★ How important scientific advances have affected national affairs and international relations is the subject of an unusual course to be introduced in the College of Arts and Science, University of Rochester, next September.

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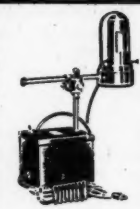

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